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DRAFT FINAL REPORT

ECOLOGICAL LIFE HISTORY OF THE DESERT KIT FOX IN THE MOJAVE DESERT OF SOUTHERN CALIFORNIA

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ABSTRACT

A field study was conducted to gather information on the ecological life history requirements of the desert kit fox, *Vulpes macrotis macrotis* in the Mojave Desert of southern California. Specific goals were to: examine habitat preferences; describe denning habits; determine food sources; estimate home range size and movement patterns; determine mortality factors; and examine the potential impacts of human activities, especially the use of off-road vehicles (ORV's) on the ecology of kit fox.

Two study sites were selected in Kern County: the "control" area was on the Desert Tortoise Research Natural Area; the stressed study area was part of the Rand Open Area where indiscriminate activities are permitted.

Live-trapping, radio telemetry, and field observations were used to gather the necessary data. Seventeen field trips were made between November, 1977, and January, 1979. A total of 108 trap-nights of effort were expended trapping 20 fox in the Rand Area and 13 animals in the Tortoise Area.

Average weights of both sexes on both study sites were 2 kg. Standard measurements of males were 2-7% larger than comparable measurements of females.

A total of 67 dens were found, 33 in the Rand Area, and 34 in the Tortoise Area. All were found in loose-textured soils in a *Larrea-Schismus-Erodium* disclimax. The mean number of entrances was 6.2 and 2.8 for the Rand and Tortoise areas, respectively. Most dens were within 200 m of a road or trail. In the Rand Area 88% of the dens were occupied at one time by radio-collared fox, but only 59% of the dens in the Tortoise Area were known to be used. Individual fox on the Rand Area used an average of seven dens, most shared with their mates. Only one to three dens were used by each of the 13 fox in the Tortoise Area. Mated pairs had exclusive use of most dens in their denning territory. The sizes of dens used by mated pairs, indicated by the number of entrances, decreased after the breeding/lactation period ceased. Natal dens were an average of 2 km apart.

Estimated home range size was 200 ha. The longest dispersal movement was 32 km.

Kit fox were most active between sunset and sunrise. Occasionally they lounged around their den during daylight. However, a male was observed to be active as often during the day as he was at night.

Limited information on prey items indicated that *V. m. macrotis* were eating jackrabbits, cottontails, rodents, lizards, snakes, and birds. Kit fox may

have obtained free water from game bird guzzlers.

Adults were in reproductive condition in December and January. Females were lactating litters by early March, and pups were observed aboveground in May. Two of three pairs in the Rand Area remained together throughout the study. One pair appeared to break up just before the male was killed.

Fox in the Rand Area were known to be alive for an average of 11 months (range 8-14), and five of these animals were at least three years old when the study terminated. Ten fox in the Tortoise Area died or disappeared in one month or less, and only one animal lived for at least nine months.

Mortality factors differed between the two study areas. Two fox on the Rand Area were shot. In the Tortoise Area two fox apparently died in den cave-ins, two animals were probably killed by coyotes, and several animals showed signs of severe malnutrition at death.

The most conspicuous ectoparasites were fleas including *Pulex irritans*, which was the most numerous species, *Echidnophaga gallinacea*, and *Orchopeas leucopus*. Endoparasites included a mass of unidentified tapeworms. External anomolies included: a broken lower canine; a hardened scar on a foreleg; a glazed, reddish eye; and a ruptured cornea.

The only direct impact of ORV users on kit fox populations was the shooting of at least two animals. ORV's drove over active dens, damaged and destroyed vegetation, disturbed soils and drainage patterns, and probably killed potential prey items such as lizards. However, we were unable to demonstrate that these disturbances had a negative impact on the aspects of kit fox ecology that we studied.

INTRODUCTION

The kit fox, *Vulpes macrotis*, is a widely distributed predator in the arid habitats of western North America. Although widespread, kit fox seldom reach densities in excess of one animal per 43 hectares in California (Morrell, 1972), and may be as scarce as one animal per 1,036 ha in Utah (Egoscue, 1975).

Because of their low densities there have been few published reports documenting the ecological life history of this species (Egoscue, 1956, 1962, 1975; Laughrin, 1970; Morrell, 1972). We do know that the kit fox is a relatively unwary animal (Hall, 1946; Egoscue, 1956; 1962, Laughrin, 1970). As a result kit fox appear to be sensitive to human activities. Highway fatalities are a significant source of mortality (Egoscue, 1962; Morrell, 1972). Kit fox are also vulnerable to night hunting for predators (Laughrin, 1970; Morrell, 1972). The use of poisoned grains to control rodent populations in California poses a serious threat of unknown dimensions because kit fox may become secondary, non-target victims if they consume poisoned rodents or bait (Swick, 1973; Schitosky, 1975). It has also been suggested that indiscriminate killing and disturbance of kit fox habitats and prey by off-road vehicle enthusiasts has a serious, negative impact on the species (Laughrin, 1970).

In the San Joaquin Valley of California, kit fox populations appear to be constrained by significant losses of suitable habitat through increased agricultural development (Laughrin, 1970; Morrell, 1972; 1975). This and several of the above factors have helped justify placement of the San Joaquin kit fox, *V. m. mutica*, on the Secretary of Interior's List of Endangered and Threatened Wildlife (Anonymous, 1976). This subspecies is also considered to be rare by the California Department of Fish and Game, and it is now in the IUCN Red Book (1968) of rare and endangered species of the world.

not accurate

no longer applies.

The status of other subspecies of *V. macrotis* is poorly known. This concerns wildlife biologists and land managers faced with developing comprehensive land-use plans for areas that serve as habitat for sensitive species such as the kit fox. The U. S. Bureau of Land Management is completing such a plan for the deserts of southern California, an area that supports populations of several endangered and threatened species as well as sensitive species such as the desert kit fox, *V. m. macrotis*.

Without appropriate baseline information it will be difficult, if not impossible, to effectively manage critical habitats necessary for the well being of this and other potentially vulnerable species of wildlife. The rapidly

increasing demands of ORV (off-road vehicle) users for additional desert habitats has exacerbated the plight of species such as the kit fox. Little is known about their normal life history requirements; far less is known about their responses to potentially disruptive land uses such as those associated with ORV's.

The major goal of this project was to gather information on the ecological life history requirements of the desert kit fox, *V. m. macrotis*, in the Mojave Desert of southern California. Specific goals were to: examine habitat preferences; locate and characterize denning sites; study food habits seasonally; determine home range size and movement patterns; document sources of mortality; and examine the potential impact of human activities, especially the use of off-road vehicles, on the ecology of kit fox.

METHODS

Study Areas

Two study areas were selected in Kern County, California. The first was located on the Desert Tortoise Research Natural Area, approximately 3 kilometers northeast of California City, California (Fig. 1). This area is partially fenced and access and grazing are restricted. Although the site has a past history of disturbances by sheep grazing and wildfires, it served as a control area that was relatively free of contemporary human disturbances.

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The second study area was located in the Rand Open Area which is north of, but adjacent to, the Desert Tortoise Area. "Indiscriminate" off-road vehicle uses are permitted in the Rand Open Area. It was heavily grazed by sheep, and in several areas it adjoins agricultural developments. The Rand Area served as the treatment plot where kit fox populations were subject to periodically intensive human interference.

Both areas have similar elevational gradients (580-900 m), soil types, and floral associations. Soils below 610 m are light-textured, while those at higher elevations have coarser texture due to higher concentrations of granitic fragments. Near the ridge lines soils are shallower and contain rock fragments and outcrops.

The dominant vegetation association would be *Larrea-Ambrosia* with an understory of native forbs and grasses. However, years of grazing have reduced the sites to a *Larrea-Schismus-Erodium* disclimax. The few native winter annuals observed in 1978 were under the canopies of either unpalatable or thorny shrubs. There were few native plants germinating between shrubs. *Ambrosia dumosa* contributes far less to the plant cover than expected since most plants have either been eaten or trampled.

Live-trapping Fox

Kit fox were trapped using two types of collapsible, wire mesh live traps: double-door traps measuring 38 x 38 x 107 cm; single-door traps measuring 30 x 30 x 76 cm. Although our personal preference was for the larger trap, fox were successfully caught in both types.

Trapping sites were almost always at or near either active or inactive kit fox dens. On a few occasions traps were operated at road intersections or in wash areas away from dens. Traps were placed on level ground near an active

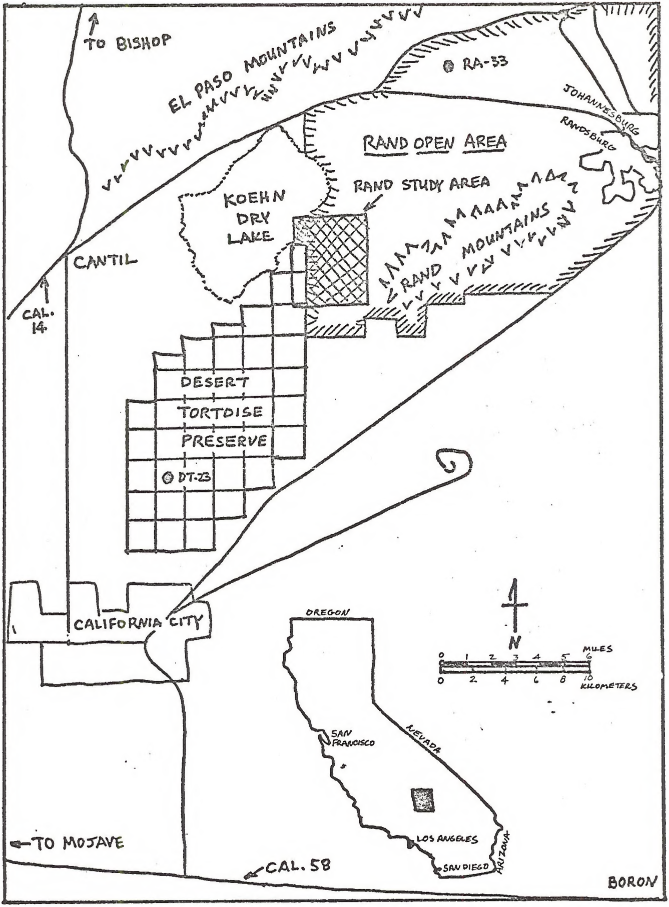

Fig. 1. Location of kit fox study sites on the Rand Open Area and Desert Tortoise Preserve, Kern County, California. Dens DT-23 and RA-33 are the first capture and final recovery sites for fox #345.

entrance to a den or in close proximity to several entrances. The "back" doors of double-door traps were closed. Fresh dirt was placed between the entrance and treadle of each trap to provide fox with a more natural surface than the wire mesh. The treadle mechanism was then checked to insure that it and the trap door were operational.

Bait was wired to the back door of double door traps or to the ceiling of single-door traps. The bait was placed in such a way that fox could not disturb it from the outside of the trap, but had to enter the trap to retrieve it. During the study we used the following bait items: sardines in cheese cloth bags; chicken bones; road-killed birds; ground squirrels; and pieces of freshly killed jackrabbits. We were unsuccessful using sardines. The natural food items, especially jackrabbit meat, were superior baits.

Traps were set at various hours throughout the day, and several were set in the evening shortly after sunset. Traps were checked every morning as close to sunrise as possible to minimize exposure of trapped animals.

Handling Animals

Captured fox were handled as quickly and humanely as possible to minimize any trauma. An investigator with heavy gloves carefully lifted the trap until he could open the front door. He then slowly entered the trap until his head, and both arms up to the shoulders, and a heavy pillowcase were inside. The fox usually cowered in the opposite end of the trap, and few tried to rush for the front door which was usually blocked by the investigator's body. The pillowcase was used to distract the fox and to cover his head and eyes. When distracted, the fox was quickly grasped by the nape and withdrawn from the trap using the free hand to balance the body. When grasped in this way most animals became submissive and ceased struggling. The animal was placed on the ground with the pillowcase covering its eyes, and its rump and hind legs firmly held between the knees and legs of the kneeling trapper.

A radio transmitter and collar were then prepared by removing the magnet and checking that the set was operating. The optimum tuning setting was recorded. Next, the collar was sized by placing it around the neck of the fox until it was snug enough to fit the neck circumference plus the width of the trapper's fingers. This prevented the collar from either slipping off due to looseness, or interfering with the fox's breathing or swallowing. Excess collar material was cut off and the unit weighed on a portable spring scale. The sized radio-collar was then placed around the neck a second time and secured with self-locking nuts.

A numbered, metal ear tag, supplied by the California Department of Fish and Game, was secured to the fox's ear: right ear in males; left ear for females. The ear tags provide long-term identification of individuals.

Measurement of the right ear from the notch was then taken and recorded. Observations of the animals' sex, sexual condition, and any abnormalities were made and recorded. Fleas and other ectoparasites were observed for relative numbers before samples were taken and preserved in vials filled with alcohol. Finally, the animals were weighed on a portable scale and released at the point of capture. Their behavior upon release was noted, especially whether they entered the den being trapped, or what direction they moved towards.

Radio Techniques

The lightweight (100 g) radio transmitters (Model Mark II, Telonics, Inc.) operated at individual frequencies between 150.2 and 151.1 MHz. Each was equipped with an integral, flexible whip antenna. The units were secured to collars made of a urethane-coated nylon webbing.

A multi-channel receiver (Model TR-1, Telonics, Inc.) was used throughout the study. It was lightweight, and allowed for rapid selection of channels under all lighting conditions. It could be operated either on batteries or by using a cord attached to the car lighter. Audio was facilitated either by an integral miniature speaker or with the use of headphones. Gain and tuning knobs allowed control over signal strength and tuning for precise directional work.

Two types of antennae were used. An omni-directional, whip antenna was magnetically attached to the roof of the field vehicle. It was used to locate signals while driving over large areas. Once a signal was perceived using the omni-antenna, a multi-element, "H"-shaped, hand-held antenna was used to more accurately determine the bearings. Initially the antenna was held in a vertical configuration while the operator slowly made a 360° circle to locate the source of the signal. Once located, the antenna was held in a horizontal plane and slowly swung in a decreasing arc to determine the bearing to the signal.

Positions of animals were then determined in one of two ways, either by triangulation or by following the signal to its source. Triangulation was accomplished by finding known map locations within the transmission area of an animal. Both the gain and tuning would be reduced slowly until only a faint "thump" could be heard while swinging the antenna in a decreasing arc. The direction of the strongest signal was then noted either by placing an object on the ground or observing a feature in the distant terrain in that direction.

A compass bearing to the point of greatest signal was then taken and recorded. The radio operator then quickly moved to another known point within the area and repeated the procedure. The intersection of the two bearings on a map indicated the approximate location of the radio-collared animal.

Tracking was done by swinging the antenna in a 100-150° arc to detect the direction of the strongest signal while simultaneously walking in that direction. As the signal strength increased the gain was reduced as an aid in finding the correct bearing. As long as the animal was not moving aboveground, this was an easy way to find collared fox. The location could then be mapped by taking compass bearings off 2-3 known peaks in the area.

Additional techniques were used when the topography and other conditions interfered with reception of radios. One of the easiest was to find prominent hills or overlooks that would place the radio operator in line-of-sight with a number of transmitters below him. Greater range could also be achieved by placing the antenna on a 3-meter boom constructed of two pieces of threaded conduit. The extra elevation often helped receive signals that were not picked up at ground level.

The directional antenna was attached to the wing strut of a Super Cub with a hose clamp, and an extension cord taped between it and the receiver inside the aircraft. Once airborne, the operator could rapidly locate animals that were being missed during ground reconnaissance. The aircraft was flown in the direction of the greatest signal strength. When the signal shifted, indicating that it had been passed, a flight line in the new direction was flown until a point on the ground was finally located that probably contained the animal. The exact spot could often be detected by pointing the aircraft, and directional antenna, at the suspected location, in much the same way this was done while walking on the ground.

The radios were useful for locating dead fox underground, but only after the following methods were developed empirically. Dead animals were noted when they were not detected to either move their location underground, and/or were not located moving on the surface during the night. To minimize digging efforts the carcass was located accurately by carefully taking directional bearings on the radio over an ever decreasing grid on the surface above the den. The antenna was held perpendicular to the ground and as close to the surface as obstructions would permit. The operator walked slowly across the suspected spot under which

the fox was located. As the signal was first perceived a mark was scuffed in the soil, and a second was scuffed as the signal disappeared. By crossing back and forth an initial square was described by the scuff marks. The tuning and gain were then reduced until a "thump" could barely be heard by the operator, and the procedure was repeated until the size of the scuffed square had been reduced to about the width of the antenna. The carcass was then dug up and was always within a 1-meter radius of the surface location.

Uses of Radio Data

Radio-collared fox were used to locate many new dens. At each site the number of entrances, whether they were fox or tortoise burrows, and the amount of den ejecta were noted. The elevation, soil type, and major vegetation association were described, as well as the distance to the nearest mappable road. Observations were made of fresh tracks, food items, and presence of scats. Samples of scats and food items were collected for later analysis. A judgment was made whether the den was active or inactive and a unique code number was assigned. Finally, the location of the den was placed on topographic maps using compass bearings to prominent land features.

Occupancy of dens was determined by locating as many collared fox in their dens as possible each day of the field sessions. Collared pairs occupying the same dens were located in this way too.

The beginning and cessation of aboveground periods of activity were determined by waiting near active dens and noting the times collared fox left or entered their dens. This was possible in the dark by using changes in radio signals. Game bird guzzlers were also monitored in this way to see if fox also used them to obtain free water.

Movements of fox during the night were obtained by triangulating on them throughout the night. In addition to these local movements, the radio-collars were used to plot migrational or dispersal movements.

And, as mentioned above, the radio-collars were used to locate dead fox as soon as possible so that we could determine mortality factors.

Food Items and Prey Base

Data on food items were gathered in two main ways. First, remains of prey items left on or near dens were counted and recorded. Secondly, fresh kit fox scats were collected each trapping session. They are being held for analysis of major food items as shown by undigested fragments in the feces.

Published information (Egoscue, 1962; Morrell, 1972) showed that the kangaroo rat and jackrabbit were probably the most important prey items. Their relative abundance on the two study areas was determined by trapping and road surveys. Rodents were surveyed by live-trapping. Two parallel lines of 20 Sherman live-traps each were extended through typical habitats in the study areas. They were operated several times during the year. Each trap was opened at sunset and baited with a mixture of oatmeal/peanut butter or mixed wild bird seed. At sunrise the next day traps were checked and captured animals identified and released.

Leporids were tallied throughout the investigation to index abundance by the number observed in each study area.

Post-mortum Observations

Dead fox were found as soon as possible to allow us to gather as much information as possible. External measurements including: total length; tail; right hind foot; right ear from notch; and weight were taken for all animals that were not mummified. External condition was noted, especially the presence of injuries, blood, ectoparasites, feces, and obvious anomolies. If an animal were not badly decomposed, a mid-ventral incision was made from the larynx to the urogenital openings. Each organ and various tissues were observed for gross lesions and the stage of decomposition. The gastrointestinal tract was checked for food items and endoparasites. Reproductive organs were observed for general condition and embryos were counted and measured.

The skull, right femur, and baculum were removed from all animals, even those too badly decomposed to undergo the above necropsy protocol. Bones were later stripped of excess flesh, soaked in water, and cleaned. They will be submitted to a museum collection.

A fox that was killed within minutes of being found was sent to the Wildlife Investigations Laboratory, California Department of Fish and Game, Sacramento, where Dr. Jessup conducted a complete gross necropsy to determine probable cause of death and general condition of the animal.

Human Impacts

Since one of the most important objectives of this project was to study the possible impacts of human activities on kit fox populations, notes were kept of all human activities in the study areas. These included observations of the numbers and types of ORV's using the areas when we were in the field, the activities of the ORV users, the use of campgrounds, and the presence of grazing

animals, especially sheep. Special efforts were made to observe and describe any human activities that might affect the kit fox populations.

Tortoises

Since the study areas occupied parts of Desert Tortoise Research Area and adjacent habitats, we made every effort to maintain records of the numbers of tortoises observed, their locations, and sizes. In most cases the length and width of the carapace was measured, but sometimes the length was merely estimated. Tortoises were removed from roads to protect them from automobiles, and none were known to have been killed by us while driving many hundreds of miles in the study areas.

Other Observations

In addition to the field notes taken for the above reasons, notes were also made of other wildlife observed by us. We also kept notes on important phenological information such as weather conditions and status of the natural vegetation.

RESULTS

Live-trapping of Fox

A total of three trapping sessions were conducted in the Rand Open Area; six sessions were conducted in the Tortoise Preserve (Table 1). In the former area 13 individual fox (6 ♂; 7♀) were captured 20 times. Three fox were recaptured once, while two fox were recaptured twice each. The overall trapping success on the Rand Area was 34%. Fox trapping was more difficult in the Tortoise Preserve. Although trapping effort was increased to 149 trap-nights (trap-nights = product of the number of traps set and the number of nights operated) only 13 individual fox (8 ♂; 5 ♀) were trapped. None were ever retrapped.The trapping success in the Tortoise Area was only 9%. Complete trapping information for all fox can be found in Appendix 1.

Average weights of fox live-trapped in the Rand Area were 1,925 g for males and 2,010 g for females (Table 2; Appendix 1). The average weights for both sexes appeared to increase between March, 1978 and January, 1979. The increased average weights of the females may have been due in part to their being pregnant in January.

Average weights of fox live-trapped in the Tortoise Area were 2,120 g for males and 1,818 g for females. The average weights for males increased about 5% between March, 1978 and January, 1979.

Ear lengths of both sexes trapped in the Rand Area averaged 83 mm. In the Tortoise Area ear from notch measurements of males averaged 84 mm, while those taken from females averaged 80 mm. Ear measurements for all animals are contained in Appendix 1.

Six fox (3 ♂; 3 ♀) were measured shortly after death on the Tortoise Area. Averages of these standard measurements were: (Males) total length, 797 mm; tail, 320 mm, right hind foot, 127 mm; right ear from notch, 86 mm; (Females) total length, 772 mm; tail, 302 mm; hind foot, 125 mm; right ear from notch, 80 mm.

Fleas were commonly observed throughout the year. Between November and March it appeared that densities of fleas were much greater on females than on males. Seven vials of fleas were identified by Harold J. Egoscue, formerly of the Smithsonian Institution, National Zoological Park. Six of the vials contained only *Pulex irritans*, but a vial of fleas taken from male 344 on the Desert Tortoise Area contained *Echidnophaga gallinacea* and *Orchopeas leucopus*

Table 1. Summary of Kit Fox trapping effort on the Rand and Desert Tortoise areas, Kern County, California, 1977-1979.

	Rand Area		Tortoise Area	
Date	Traps set	Fox caught	Traps set	Fox caught
Nov. 1977	3	2		
March 1978	18	6	48	3
April 1978			39	1
Sept. 1978			18	2
Nov. 1978			8	0
Dec. 1978			22	4
Jan. 1979	38	12 (1 Badger)	14	3
Totals	59	20 (34%)	149	13 (9%)

Table 2. Weights (g) of Kit Fox trapped on the Rand and Desert Tortoise areas, Kern County, California, 1978-1979.

	Rand Area		Tortoise Area	
Date	Males	Females	Males	Females
March, 1978	1,967	1,828	1,907	1,624
	1,784	1,730	2,172	
	1,727			
Mean	1,826	1,779	2,039	
April, 1978			1,545	
September, 1978			2,710	1,990
December, 1978			2,277	1,815
				1,945
				1,716
Mean				1,825
January, 1979	1,900	2,050	2,459	
	2,000	2,275	1,729	
	2,025	1,800	2,240	
	2,075	1,925		
		2,450		
		2,025		
Mean	2,000	2,087	2,143	
Grand Mean	1,925	2,010	2,130	1,818
Standard Error	49	247	384	153

in addition to specimens of *Pulex irritans*. Eighteen vials of fleas are awaiting taxonomic identification.

Only four abnormalities were observed on live-trapped fox, none of which resulted from the trapping or tagging operation. In the Rand Area male 339 had a broken lower left canine. In the Tortoise Area: male 344 had a hardened scar on his right foreleg; female 347 had a reddish, glazed left eye that may have been due to an injury; male 338 had a ruptured right cornea that may have been due to a recent injury.

Radio transmitter collars were attached to six fox (3 ♂; 3 ♀) in the Rand Area, and to all 13 fox (8 ♂ ; 5 ♀) live-trapped in the Tortoise Area. The average weight of the radio-collars was 100 g which is approximately 5% of the average live-weight of the foxes collared. This is within the range of collar weights recommended by telemetry experts. We gathered no data that indicated that the collars were too heavy or interfered with the normal functions of the fox.

Kit Fox Dens

A total of 67 kit fox dens were observed and described between November, 1977, and January, 1979: 33 were found in the Rand area, while 34 were found in the Tortoise Area. Complete information on location, description, method of discovery, and occupancy of dens by fox is given in Tables 3 and 4.

In the Rand Area (Table 3) only 7 of 33 dens were found by observers hiking or driving through the area; most of the dens were found by tracking six radio-collared fox to new dens (157 radio-fixes). In the Tortoise Area (Table 4) approximately half the dens were found by observation, while tracking the 13 collared animals (131 radio-fixes) yielded only 20 new den sites.

The number of entrances to kit fox dens is thought to indicate the relative age of the den and some of its uses. Older, natal dens have more entrances than younger, daily shelter dens. The average number of entrances to kit fox dens observed was 6.2 and 2.8 for the Rand and Tortoise areas, respectively (Table 5). The means are significantly different. The greater number of entrances in the Rand Area dens is also shown by the fact that 33% of the dens there had more than five entrances, while on the Tortoise Area only two dens had more than five entrances. The largest dens (> 10 entrances) were all found in the Rand Area.

The mean elevation of dens in the Rand Area was 667 m (range 585-770 m), which was significantly lower than the average elevation of 733 m for the Tortoise Area dens (Table 6). The differences in elevation probably are not

Table 3. Location, description, method of discovery, and occupancy of Kit Fox dens, Rand Open Area Kern County, California, 1977-1979.

I.D. No.	Location[1]	Distance from road (m)	Eleva- tion (m)	Number of Entrances	Discovered By	Animals Trapped	Animals Located in Den by Radio
RA-1	SW¼, SW¼, Sec. 18, T30S, R39E	100	620	8 (11/77); 9 (1/79)	Observation	269;272 339	272;339 (paired)
RA-2	NE¼, NE¼, Sec. 24, T30S, R38E	470	620	8 (7/78	Radio Fixes		272;339 (paired)
RA-3	SE¼, SE¼, Sec. 13, T30S, R38E	150	615	1 (3/78)	Radio Fixes		339
RA-4	SW¼, NE¼, Sec. 19, T30S, R39E	300	675	8 (1/79)	Observation	341;342	340;341
RA-5	SE¼, NE¼, Sec. 19, T30S, R39E	20	620	4 (1/79)	Observation		342
RA-6	SE¼, NE¼, Sec. 19, T30S, R39E	50	690	6 (1/79	Radio Fixes	274	340;342
RA-7	NE¼, SE¼, Sec. 19; T30S, R39E	250	705	3 (1/79)	Radio Fixes		342
RA-8	NE¼, NE¼, Sec. 19, T30S, R38E	15	685	3 (11/77)	Observation		
RA-9	NE¼, NE¼, Sec. 19, T30S, R39E	200	675	3 (7/78)	Radio Fixes	274;340	274;341
RA-10	NE¼, NE¼, Sec. 19, T30S, R39E	200	675	18 (7/78)	Radio Fixes	273;341	274;341 (paired)
RA-11	SW¼, SW¼, Sec. 17, T30S, R39E	80	675	5 (1/79)	Radio Fixes	268	274;341 (paired)
RA-12	NW¼, NE¼, Sec. 24, T30S, R38E	150	585	7 (5/78); 6 (1/79)	Radio Fixes		272;339 (paired)
RA-13	NW¼, NE¼, Sec. 19, T30S, R39E	200	690	1 (6/78); 1 (1/79)	Radio Fixes		340;342 (paired)
RA-14	NW¼, NW¼, Sec. 18, T30S, R39E	50	585	22 (6/78)	Observation		
RA-15	NW¼, NW¼, Sec. 18, T30S, R39E	375	595	7 (6/78)	Observation		
RA-16	SE¼, SE¼, Sec. 13, T30S, R39E	205	605	2 (7/78)	Radio Fixes	270	272;339 (paired)

Tab 3. (Cont'd) Location, description, method o scovery, and occupancy of Kit Fox dens, Rand O Area
Kern County, California, 1977-1979.

I.D. No.	Location[1]	Distance from road (m)	Elevation (m)	Number of Entrances	Discovered By	Animals Trapped	Animals Located in Den by Radio
RA-17	NE¼, NE¼, Sec. 19, T30S, R39E	55	680	3 (7/78)	Radio Fixes	275	274; 340;342 (paired)
RA-18	SW¼, SW¼, Sec. 17, T30S, R39E	65	675	2 (7/78)	Radio Fixes		341
RA-19	NE¼, SE¼, Sec. 17, T30S, R39E	192	680	3 (7/78)	Radio Fixes		274
RA-20	NE¼, SE¼, Sec. 17, T30S, R39E	178	690	1 (7/78)	Radio Fixes		274
RA-21	SW¼, SW¼, Sec. 17, T30S, R39E	147	675	2 (7/78)	Radio Fixes		341
RA-22	NE¼, NE¼, Sec. 19, T30S, R39E	225	680	2 (7/78)	Radio Fixes		274
RA-23	NE¼, SE¼, Sec. 13, T30S, R38E	95	680	2 (8/78)	Radio Fixes		339
RA-24	SW¼, SW¼, Sec. 18, T30S, R39E	30	615	3 (1/79)	Radio Fixes		272
RA-25	SE¼, SW¼, Sec. 18, T30S, R39E	45	635	2 (8/78)	Radio Fixes		274
RA-26	NE¼, NE¼, Sec. 24, T30S, R38E	450	680	2 (8/78)	Radio Fixes		272;339 (paired)
RA-27	NW¼, NE¼, Sec. 19, T30S, R39E	55	680	1 (10/78)	Radio Fixes		340;342 (paired)
RA-28	NE¼, SE¼, Sec. 19, T30S, R39E	85	705	3 (12/78)	Radio Fixes	267	340
RA-29	NE¼, SE¼, Sec. 19, T30S, R39E	97	705	5 (12/78)	Observation		
RA-30	NE¼, NW¼, Sec. 29, T30S, R39E	800	770	1 (1/79)	Radio Fixes		340
RA-31	NW¼, SW¼, Sec. 19, T30S, R39E	1200	660	7 (1/79)	Radio Fixes	339	339
RA-32	NE¼, SE¼, Sec. 19, T30S, R39E	100	715	6 (1/79)	Radio Fixes	273;274; 595	274
RA-33	NE¼, NE¼, Sec. 23, T29S, R39E	200	695	12 (1/79)	Radio Fixes		345

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[1] Saltdale SE Quadrangle

Ta[illegible] 4. Location, description, method of discove[illegible]nd occupancy of Kit Fox dens, Desert Tortoise [illegible]tural Area Kern County, California, 1977-1979.

I.D. No.	Location[1]	Distance from road (m)	Elevation (m)	Number of Entrances	Discovered By	Animals Trapped	Animals Located in Den by Radio
DT-1	SE¼, SW¼, Sec. 18, T31S, R38E	2	675	2 (3/78)	Observation	344	
DT-2	NW¼, NE¼, Sec. 19, T31S, R38E	20	680	2 (3/78)	Observation		
DT-3	SW¼, SW¼, Sec. 17, T31S, R38E	30	695	3 (6/78)	Observation	353A	
DT-4	SW¼, SW¼, Sec. 16, T31S, R38E	30	735	3 (3/78)	Observation		
DT-5	SW¼, SW¼, Sec. 16, T31S, R38E	2	740	1 (3/78)	Observation		
DT-6	NE¼, NE¼, Sec. 21, T31S, R38E	12	775	4 (6/78)	Observation		
DT-7	SW¼, SW¼, Sec. 15, T31S, R38E	19	785	4 (6/78)	Observation	336	
DT-8	NE¼, NW¼, Sec. 22, T31S, R38E	165	790	3 (6/78)	Radio Fixes		336;337 (paired)
DT-9	NE¼, NW¼, Sec. 22, T31S, R38E	42	795	8 (6/78)	Observation	337	338
DT-10	NW¼, NE¼, Sec. 22, T31S, R38E	25	800	5 (6/78)	Observation		
DT-11	NW¼, NE¼, Sec. 22, T31S, R38E	35	805	5 (6/78)	Observation	338	
DT-12	SE¼, SE¼, Sec. 15, T31S, R38E	20	815	2 (6/78)	Radio Fixes		338
DT-13	NW¼, SW¼, Sec. 14, T31S, R38E	27	830	3 (7/78)	Observation		
DT-14	NW¼, NE¼, Sec. 21, T31S, R38E	15	765	2 (4/78)	Observation		
DT-15	SW¼, NE¼, Sec. 21, T31S, R38E	400	760	1 (6/78)	Radio Fixes		336
DT-16	SE¼, NW¼, Sec. 21, T31S, R38E	800	750	3 (4/78)	Radio Fixes		337;345;348
DT-17	NW¼, NE¼, Sec. 19, T31S, R38E	10	680	1 (4/78)	Radio Fixes		

Table [illegible] (Cont'd) Location, description, method of di[illegible]ery, and occupancy of Kit Fox dens, Desert To[illegible]se Natural Area, Kern County, California, 1977-1979.

I.D. No.	Location[1]	Distance from road (m)	Eleva-tion (m)	Number of Entrances	Discovered By	Animals Trapped	Animals Located in Den by Radio
DT-18	NW¼, NW¼, Sec. 23, T31S, R37E	100	675	2 (4/78)	Radio Fixes		344
DT-19	SE¼, SW¼, Sec. 16, T31S, R38E	150	745	1 (5/78)	Radio Fixes		337
DT-20	NE¼, NW¼, Sec. 22, T31S, R38E	175	790	5 (7/78)	Observation		
DT-21	SE¼, SE¼, Sec. 36, T31S, T37E	150	695	1 (8/78); 4 (1/79)	Radio Fixes		344
DT-22	SW¼, NW¼, Sec. 19, T31S, R38E	575	675	5 (9/78)	Radio Fixes		353A
DT-23	SE¼, NE¼, Sec. 20, T31S, R38E	175	730	3 (9/78)	Radio Fixes	345;348	345;348;352A
DT-24	NW¼, NE¼, Sec. 28, T31S, R38E	775	755	4 (10/78)	Radio Fixes		352A
DT-25	NE¼, NW¼, Sec. 20, T31S, R38E	45	710	2 (9/78)	Observation	352A	
DT-26	NW¼, SE¼, Sec. 25, T31S, R37E	170	690	2 (10/78); 3 (1/79)	Radio Fixes		344
DT-27	NE¼, SW¼, Sec. 29, T31S, R38E	280	715	7 (11/78)	Radio Fixes		352A
DT-28	SE¼, NW¼, Sec. 29, T31S, R38E	0	715	1 (12/78)	Radio Fixes		347
DT-29	NE¼, NW¼, Sec. 31, T31S, R38E	5	700	1 (12/78)	Radio Fixes		346
DT-30	SE¼, SW¼, Sec. 24, T31S, R37E	500	675	1 (1/79)	Radio Fixes	349;351A	346;351A
DT-31	SE¼, SW¼, Sec. 24, T31S, R37E	500	675	2 (1/79)	Radio Fixes	350	346;347;351A
DT-32	SE¼, SE¼, Sec. 23, T31S, R37E	25	675	2 (1/79)	Radio Fixes		350
DT-33	NE¼, SW¼, Sec. 23, T31S, R37E	100	675	3 (1/79)	Radio Fixes		349;350
DT-34	NW¼, SW¼, Sec. 16, T31S, R38E	150	740	2 (1/79)	Radio Fixes		348

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[1] Castle Butte, Calif. Quadrangle

Table 5. Number of entrances to Kit Fox dens on the Rand and Desert Tortoise areas, Kern County, California, 1977-1979.

Number of Entrances	Rand Area	Tortoise Area
1	5	8
2	7	10
3	7	7
4	1	3
5	2	4
6	2	
7	3	1
8	2	1
9	1	
12	1	
18	1	
22	1	
Number	33	34
Mean (± SE)	6.2 ± 1.1*	2.8 ± 0.3
Median	3	2

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*Significant difference between means ($P < 0.05$)

Table 6. Elevation of Kit Fox burrows on the Rand and Desert Tortoise areas, Kern County, California, 1977-1979.

	Rand Area	Tortoise Area
Mean elevation (± S. E.) meters	667 (± 7)*	733 (± 8)
Range	585-770	675-830

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*Significant difference between means ($P < 0.05$).

significant ecologically, but instead, represent samplings of two areas that differ as regards the proportion of lower elevation habitats available.

Surprisingly, many of the kit fox dens, even those discovered by tracking radio-collared animals, were in close proximity to roads and jeep trails (Table 7). The average distance between kit fox dens and the nearest road was 207 and 163 m for the Rand and Tortoise areas, respectively. Only four of the dens, two on the Rand Area and two on the Tortoise Area, were located more than 500 m from a road. More than half of the dens on the Tortoise Area were less than 50 m from a road or trail.

Almost all of the dens were located on gradual, west to northwest-facing slopes dominated by a *Larrea-Schismus-Erodium* disclimax. Soils were characteristically deep, light textured, and virtually stoneless at depths of 1.5 m. There was no observable caliche or hard pan layer, and dens were usually placed in well-drained areas.

We found three atypical dens. A mated pair in the Rand Area occupied a single entrance den placed between rock layers on the north-facing slope of a small hill at an elevation of 690 m. Another den was located in a culvert under a well-used access road to a recreational vehicle rendezvous and camping site in the Rand Mountains. A third den was found next to a steel well casing on the Desert Tortoise Area. The soil adjacent to the casing had eroded in places to 1-1.5 m. The fox gained access to a horizontal den opening after dropping down along the casing.

All but four of the 33 dens located in the Rand Area were occupied by radio-collared fox at some time (Table 8). Of the occupied dens, 18 were used by single fox, 10 were used by two fox, and one den was used by three collared fox. Nine of the dens used by two fox were occupied by mated pairs, while one was used by two lone fox. The den used by three fox housed a mated pair, and later, a lone fox.

In the Tortoise Area 14 of 34 dens were never used by fox carrying radios. Of the 20 dens that were used, 14 sheltered only one collared fox each, four were occupied by two fox, and two were occupied by three different fox each. Half of the dens used by two or three fox sheltered mated pairs, while the remainder were used by fox that were either unmated, or were paired with uncollared fox.

Table 7. Distance from Kit Fox dens to nearest road on the Rand and Desert Tortoise areas, Kern County, California, 1977-1979.

Distance (m)	Rand Area	Tortoise Area
0 - 25	2	12
26 - 50	4	6
51 - 75	3	
76 - 100	6	2
101 - 150	3	3
151 - 200	6	4
201 - 300	4	1
301 - 400	1	1
401 - 500	2	2
501 - 600		1
601 - 700		
701 - 800	1	2
1200	1	
Mean (± S. E.)	207 ± 42	163 ± 38
Median	150	43.5

Table 8. Numbers of Kit Fox using dens on the Rand Open Area and Desert Tortoise Research Area, Kern County California, 1977-1979.

	Rand Area		Desert Tortoise Area	
No. of Fox Using Den	No. of Dens	Remarks	No. of Dens	Remarks
0	4		14	
1	18		14	
2	10	9 dens used by paired fox; 1 den by 2 lone fox.	4	2 dens used by paired fox; 2 dens by 4 lone fox.
3	1	Den used by 1 pair and one lone fox.	2	1 den used by a pair and 1 lone fox; 1 den used by 3 lone fox.
Total	33		34	

The number of dens used by individual fox on the two study areas is summarized in Table 9. The six fox in the Rand Area used an average of seven dens each (locations illustrated in figures 2 through 7) with a range of between six and 9. The majority of dens were shared with their mates. Only female 274 used more dens alone than with her mate, but most of these were occupied after he was killed.

Only between one and three dens were occupied by the 13 radio-collared fox in the Desert Tortoise Area. Only six of the fox were known to share their dens with other radio-collared fox; the majority of fox lived alone or with uncollared mates.

The sizes of dens occupied by mated pairs on the Rand Area was different during the breeding/lactation period and after. From January to the end of May, the last time pups were observed with the pairs, the average number of entrances to shared dens was 8.5 with a range of 5 to 18. From June to November/December the average number of entrances to shared dens was significantly lower ($P < 0.05$): 3.4 with a range of 1-8.

Three natal dens, or at least dens known to be occupied by mated pairs and their pups were located in the Rand Area. They were an average of 2 km apart. When the dens used by the mated pairs were mapped (Figure 8) notable patterns emerged. In spite of their proximity, the mated pairs appeared to use a series of dens exclusively. It wasn't difficult to draw lines around the dens owing to the lack of significant overlap. Only one den, RA-17, was occupied by members of more than one pair. Female 274 used the den, but only after her mate was killed.

Home Range

Our attempts to determine the home ranges, particularly those portions used for hunting, were unsuccessful. The topography of both study areas, while appearing to be relatively gentle, interfered with radio reception over a few hundred meters on most occasions. Attempts to find peaks, hills, and other high vantages did not provide us with sufficient line-of-sight reference stations for triangulation purposes. Even when animals were located from a known reference point, we were seldom able to find a second reference point at a sufficient distance and satisfactory angle, and with adequate reception to complete the task. Having only one radio receiver and operator further frustrated these efforts.

Table 9. Number of dens occupied by individual Kit Fox on the Rand Open Area and Desert Tortoise Research Area, Kern County, California, 1977-1979.

Animal Number	Number of Dens Used	Remarks
		Rand Open Area
272	6	5 dens shared with mate; 1 den alone
274	9	4 dens shared with mate; 5 dens alone
339	8	5 dens shared with mate; 3 dens alone
340	7	4 dens shared with mate; 3 dens alone
341	6	4 dens shared with mate; 2 dens alone
342	6	4 dens shared with mate; 2 dens alone
Mean = 7* s = 1.3		
		Desert Tortoise Area
336	2	1 den shared with mate; 1 den alone
337	3	1 den shared with mate; 2 dens alone
338	2	Alone
344	3	Alone
345	2	1 den shared with mate; 1 den alone
346	3	1 den shared with mate; 2 dens alone
347	1	Alone
348	3	1 den shared with mate; 2 dens alone
349	1	Alone
350	2	Alone
351A	2	1 den shared with mate; 1 den alone
352A	3	Alone
353A	1	Alone
Mean = 2.1* s = 0.8		

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*Significant difference between means ($P < 0.05$)

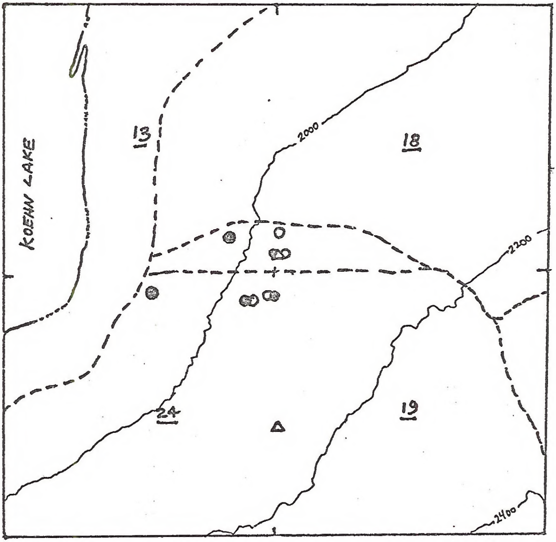

Fig. 2. Location of dens on the Rand Open Area where fox #272 was trapped or located by radio bearings. Open triangle indicates dens where fox was trapped; open circles, dens where fox was located alone; closed circles, dens where fox was located with another fox. Underlined numbers are section numbers in the Saltdale S. E. quadrangle. Contour intervals are in feet.

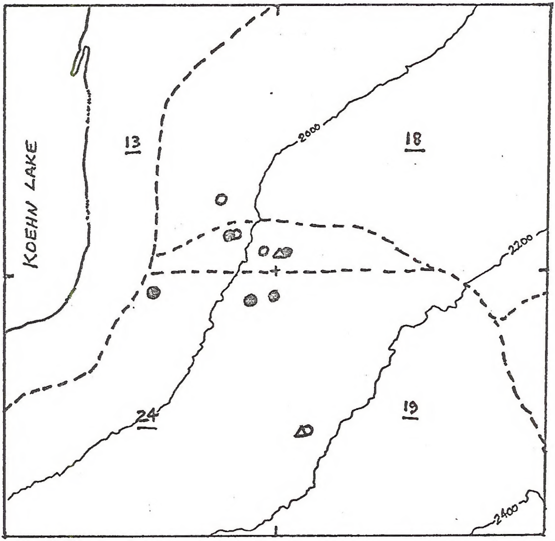

Fig. 3. Location of dens on the Rand Open area where fox #339 was trapped or located by radio bearings. Use of symbols explained in Fig. 2.

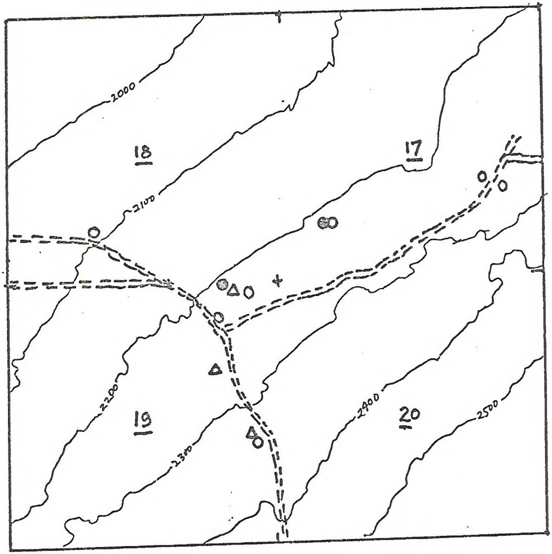

Fig. 4. Location of dens on the Rand Open area where kit fox #274 was trapped or located by radio bearings. Use of symbols explained in Fig. 2.

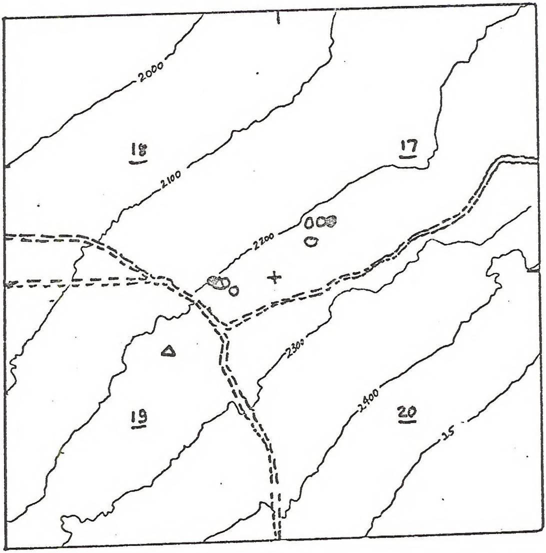

Fig. 5. Location on dens on the Rand Open Area where kit fox #341 was trapped or located by radio bearings. Use of symbols explained in Fig. 2.

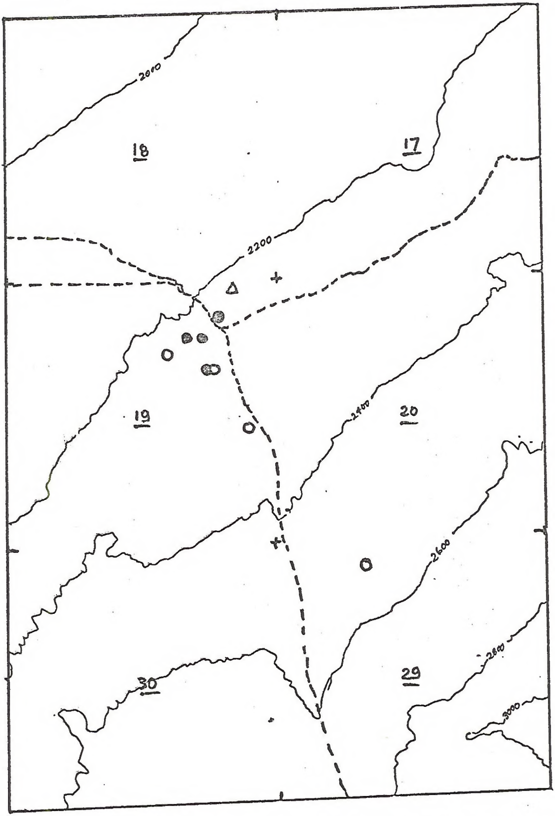

Fig. 6. Location of dens on the Rand Open Area where kit fox #340 was trapped or located by radio bearings. Use of symbols explained in Fig. 2.

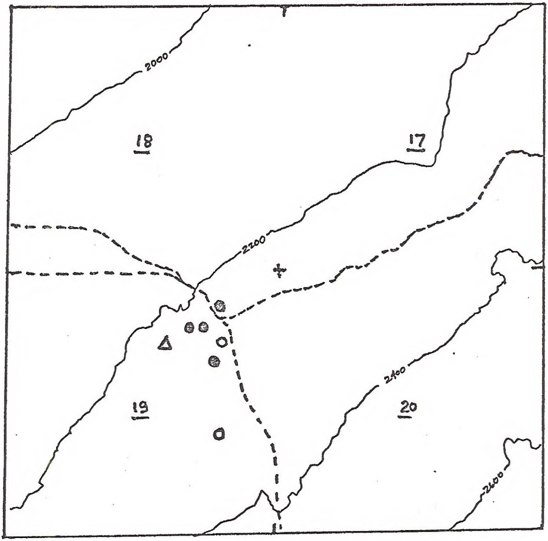

Fig. 7. Location of dens on the Rand Open Area where kit fox #342 was trapped or located by radio bearings. Use of symbols explained in Fig. 2.

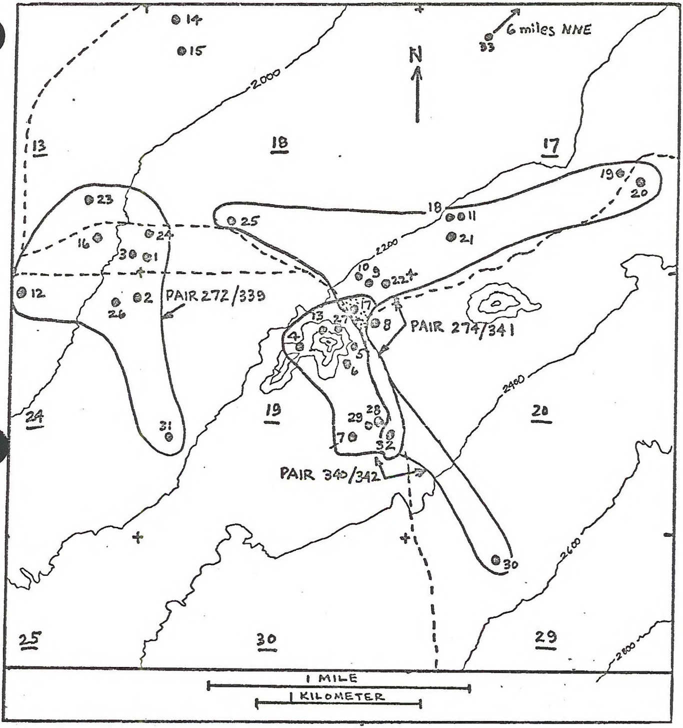

Fig. 8. Locations of dens on the Rand Open Area occupied by 3 pairs of kit fox between 1977-1979. Closed circles and numbers are den locations and codes. Den sites used by a pair are enclosed within a solid line. The stippled area at den RA-17 indicates the only known site where more than one pair used a den. Remaining symbols as in Fig. 2.

We did, however, gather a substantial amount of information on den sites as described above. If we restrict the definition of home range to "that area enclosing the den sites occupied by an individual fox," we can provide meaningful estimates of the areas occupied by fox during their denning activities.

The den sites of the six fox located more than once in the Rand Area and the 10 fox located in the Tortoise Area were mapped. The maps of the Rand Area fox are illustrated in figures 2 through 7; those for the Tortoise Area were too sparse to justify figures here. The greatest distances between den sites for each individual were measured. These averaged 1.5 and 1.7 km for the Rand and Tortoise areas, respectively. Since the means were not statistically different the values for both areas were combined to yield the mean (± S. E.) of 1.6 ± 0.4 km. If we consider the average longest distance to be the estimated diameter of a circular home range, then the mean range size for kit fox in these two areas would be 200 hectares.

Dispersal

At least two animals moved distances that indicated they were dispersing rather than moving within established home ranges. Male 344 was first caught on 2 April 1978 along the west-central border of the Desert Tortoise Preserve. Over the next eight months he was located aboveground several times, and in a series of dens between the Tortoise Preserve and California City. The greatest distance between sightings of this fox was 4.8 km.

Female 345 made the longest dispersal movement. She was first trapped in the Tortoise Area in den DT-23 on 27 December 1978. One month later she was located approximately 32 km northeast of her initial capture point in den RA-33 near the base of the El Paso Mountains (Fig. 1).

Activity Patterns

Dens were monitored to determine when the fox became active on the surface. Following a period of activity on the surface in the vicinity of the den, most fox left the area between 2000 and 2100 hours, on days that sunset was around 2000. Some fox returned to their dens between 0230 and 0300 for brief periods. Most of the fox returned to their dens between 0530 and 0600 on days the sun rose around 0530.

In May and June fox were occasionally seen on the surface in close proximity to their dens. Observations were made of surface activity between 0700 and 1800 with many of the observations between 1000 and 1400. The fox were seen lounging

around the entrances or resting in the shade of *Larrea*.

Male 344 was observed on the surface as often in daylight as he was at night. Half of the surface observations were made between 1000 and 1500. He was seen moving, and probably hunting, as well as resting in the shade.

Food Habits

Until all scats have been analyzed, information on food habits will be limited to evidence gathered from prey remains collected near active dens. This information is summarized in Table 10. Prey items were identified to genus whenever possible. For example, *Lepus* or *Sylvilagus* fur. If this were impossible a more general category. Leporidae fur, was used. Tallies under the general classifications do not include items listed in the indented specific categories. Furthermore, tallies do not indicate the number of animals represented, only the number of pieces identified. The classification of rodent tails and jaws refers to several grams of parts found, but the small size of the fragments precluded identification of numbers.

Data gathered to index populations of important prey (hares, rabbits, rodents) are synthesized in Tables 11 and 12. Rodent trapping data are summarized in Table 11. Both areas were dominated by two key Mojave Desert mammals: *Dipodomys merriami*, Merriam's kangaroo rat; *Perognathus longimembris*, little pocket mouse. There were no obvious differences in rodent densities between the Rand and Tortoise areas: 14-17 kangaroo rats were caught per 100 trap-nights; and about one pocket mouse was caught per 100 trap-nights.

Observations of jackrabbits (*Lepus californicus*) were logged as they occurred. Table 12 includes monthly summaries of the numbers observed in the two study areas. The data must be regarded as a crude index only. The same routes were not driven each month under comparable conditions. More time was spent in the Tortoise Area, particularly in late 1978, and the data have not been adjusted for the proportion of time spent in each area. As an index, the data suggest that hare populations were comparable. Our own evaluation is that hare densities were greater on the Rand Area, especially in areas adjacent to agricultural developments, and the animals were neither as wary nor as prone to run long distances at high speed as they did on the Tortoise Area.

The need for, and methods of finding free water by the kit fox are unknown. Gamebird guzzlers in the Rand Open Area were monitored throughout several nights to see if fox used them. At the end of July, male 342 was located by radio bearings in proximity to the guzzler located approximately 3.5 km south of den RA-17. He was located there several times during the night.

Table 10. Recognizable prey parts found at Kit Fox dens in the Rand and Desert Tortoise areas, Kern County, California, 1977-1979.

Mammal	Rand Area	Tortoise Area
Leporidae fur	4	1
Sylvilagus fur	1	
Lepus fur	1	
Leporidae feet and legs		1
Lepus legs and/or feet	10	
Sylvilagus legs and/or feet	1	
Leporidae head		1
Lepus head	1	
Leporidae skull	1	
Leporidae parts		
Lepus backbone and ribs	2	
Lepus, back, intestines	2	
Lepus tails	2	
Sylvilagus tails	1	
Rodent tails and jaws	1	
Reptile		
Snake skins	1	
Rattlesnake	1	
Lizard skins	1	
Lizard carcass	1	
Avian		
Bird feathers	3	1
Fringillidae feathers		1
Roadrunner feet and feathers	1	

some quite recently. A pair of fox was found living in den RA-27 in October, and flagging indicated that a planned cycle race would pass over or near the den. The next month the pair was found elsewhere, but their move may have been random and unrelated to the race.

Other Animals

Observations on four other mammals were made during the study. In late May a striped skunk, *Mephitus mephitus*, was observed walking downslope from the Rand Area towards Koehn dry lake. It was dark at the time and we were unable to observe its activities closely.

On 25 January 1979 a large badger, *Taxidea taxus*, was live-trapped in a wash just north of den RA-28. We did not have the necessary equipment to handle the animal so we released it. It immediately ran into den RA-28 where we had previously trapped and located kit fox. The entrance to the burrow didn't look as if it had been noticeably enlarged by the badger. Three badger scats were collected near the entrance of the den and live-trap.

A feral horse, *Equus caballus*, was seen near the west-central border of the Desert Tortoise Area. It had some leather around its head and must have escaped. A local resident observed the horse for several months and said that he got water from the small cabins outside the preserve.

Coyotes (*Canis latrans*) were seen several times, both in the Rand and Tortoise areas. Most notations of coyotes, their dens, or vocalizations were made in the Tortoise Area, especially in the southwestern quarter of the area. A den was found here, and in December several coyotes were heard howling during the night.

DISCUSSION

Results of the fox live-trapping efforts were the first indication that populations on the Rand and Tortoise areas were probably not comparable. Fox were readily trapped in the Rand Area as shown by the 34% overall trapping success. Several animals were recaptured, two of them twice each after their initial captures.

In spite of increased efforts in the Tortoise Area, the overall trapping success was only 9%, and none of the animals were recaptured. The trapping data suggested that fox populations in the Tortoise Area were less dense than on the Rand Area. Since the Tortoise Area was chosen as the "control" study site, further comparisons between fox populations on this and the stressed site, or Rand Open Area, were difficult if not impossible to make.

The animals live-trapped in both areas were comparable as regards standard measurements and weight. Adults of both sexes weighed about 2 kg. Grinnell et al., (1937) reported that male *V. m. mutica* were 15% heavier than females, and Egoscue (1962) found that *V. m. nevadensis* males were 8% heavier than non-pregnant females. Our data did not show marked sexual dimorphism in weights of *V. m. macrotis*.

Our data did confirm that standard measurements of females were 2-7% smaller than those of males (Grinnell et al., 1937). Standard measurements taken from fox that died during this study compared closely with those reported by Grinnell et al., (1937) and Hall (1946).

Kit fox dens in the Rand and Tortoise areas occupied sites with similar soils, exposure, elevation, and vegetation associations. Soils were always loose-textured and free of rocks or stones. Most authors have associated the kit fox with loose-textured soils (Burt, 1934; Hall, 1946; Egoscue, 1962; Laughrin, 1970; Morrell, 1972). No dens were found in soils containing a hard pan or caliche layer. Morrell (1972) has reported that it might be difficult for kit fox to dig in soils with a hard pan unless other animals, such as badger, break the impervious layer. Few of the dens were found in the sandy soils at elevations below 670 m. None were found at elevations above 820 m where the soils were generally shallow and rocky. The significant difference between mean elevation of the den sites on the two study areas probably represented the fact that optimal textured soils reached lower elevations in the Rand Area than they did in areas we trapped in the Tortoise Area.

All dens were found in vegetation associations that would normally be dominated by *Larrea-Ambrosia*, but are now a *Larrea-Schismus-Erodium* disclimax. Kit fox have been studied in other areas where the dominant vegetation included: dunes vegetated with *Atriplex; Sarcobatus;* shadscale flats dominated by *Atriplex confertifolia; Larrea-Ambrosia;* and annual grasslands (Burt, 1934; Allred et al., 1963; Egoscue, 1962; Jorgensen and Hayward, 1965; Laughrin, 1970; Morrell, 1972).

Our finding that kit fox dens were within 150 to 200 m of roads or jeep trails surprised us. We anticipated that fox would select areas remote from human habitations or disturbances whenever possible. This was not the case during our period of observations, and few dens were found to be more than 300 m away from roads. We might speculate that the roads and trails provide the fox with additional paths having increased visibility for hunting.

The mean number of entrances to kit fox dens in the Rand Area (6.2) was significantly greater than that observed for dens in the Tortoise Area (2.8). A third of the dens in the Rand Area had more than 5 entrances, and only five dens consisted of a single entrance. Only two Tortoise Area dens had more than five entrances, but 23% had single entrances. If we accept the premise that older, natal dens have more entrances than younger, daily-use shelter dens, we conclude that in 1977-1979 the Rand Area provided a more optimal habitat than the Desert Tortoise Reserve, especially for natal den sites. This conclusion is further supported by our lack of evidence of breeding in the Tortoise Area, and the relatively short duration of trappability displayed by fox in the Tortoise Area.

In Utah, kit fox dens had between two and seven entrances, although one den had 24 (Egoscue, 1962). Data from California indicated that *V. m. mutica* dens consisted of one to ten entrances, although most dens had just two entrances (Morrell, 1971). The Kern County kit fox dens we observed had an average number of entrances more similar to their Utah cousins than to nearby populations of *V. m. mutica*.

Three anomolous den sites were found and described. One of these dens was constructed in soil, as most normal dens are, but it was located in an unusual location: adjacent to an abandoned steel well casing. A second den was located in a culvert under a well-used road leading to a popular campground. Egoscue (1956) also reported that kit fox occasionally used culverts as dens. The third den, between rock layers on a low hill, was the most unusual den location since the single entrance appeared to be in solid rock.

In the Rand Area 88% of the dens were used by radio-collared fox during the study. Most of the occupied dens were used either by lone fox or by mated pairs. In the Tortoise Area only 59% of the known dens were ever occupied by collared fox. Egoscue (1962) also reported that study areas in Utah contained a mixture of occupied and deteriorating dens.

Individual fox in the Rand Area used an average of seven dens each, while animals on the Desert Tortoise Area used only one to three dens. The differences in the average number of dens occupied were probably due to the short duration that radio-collared fox remained or lived in the Tortoise Area. If more fox had lived longer on the Tortoise Area we may have found them using as many dens as their neighbors on the Rand Area.

Our findings that mated fox occupied larger dens during the breeding/lactation period than they did during the remainder of the year confirms Morrell's (1972) findings. He concluded that San Joaquin kit fox occupy smaller dens during the three months following the breeding season. The importance of the larger natal dens for successful breeding is only now becoming appreciated (Egoscue, 1962; Morrell, 1972).

The spacing of natal dens may also be important in the territorial requirements of kit fox. The three natal dens found in this study were about 2 km apart. Those found in Utah were 3.2 km apart (Egoscue, 1956, 1962).

Our data provide further support to earlier observations that mated pairs use certain sets of dens exclusively (Morrell, 1972). The degree of exclusivity is graphically illustrated in Figure 8 where the dens of mated pairs are outlined.

Information on exclusive denning sites suggests a territorial allocation of available habitat. Egoscue (1975) believed that the maximum carrying capacity of the area for foxes is primarily related to their territorial requirements. Our data on the greatest distances between denning locations indicated an estimated home range of about 200 ha. This figure is comparable with Morrell's (1972) estimate of 260 to 520 ha for *V. m. mutica* in California.

Information on kit fox densities further suggests that this species is widely spaced in its optimum habitats. In Utah densities were reported to be one fox per 471 to 1,036 ha (Egoscue, 1962, 1975). California populations in the San Joaquin Valley have been estimated at between one fox per 43 to 260 ha (Laughrin, 1970; Morrell, 1972).

The longest dispersal movement recorded in this study was 32 km. This is identical to two dispersal movements recorded by Egoscue (1962) in Utah. He

showed that pups did not establish residence in the area of their birth. The dispersal movements recorded in Utah and California may have represented dispersal of juvenals from their natal sites to new ranges.

Kit fox are primarily nocturnal although some diurnal activity around the den takes place (Egoscue, 1962; Morrell, 1972). We likewise found that fox observed during this study were active most often during the night. They commenced their activities near sunset, as did the activities of fox studied by Egoscue (1956) and Morrell (1972). Occasionally animals returned to their dens for brief periods during the night, but most stayed out until sunrise. This also agrees with the findings of Egoscue (1956) and Morrell (1962). Some activity, especially resting and grooming, was observed adjacent to the den during the day, even near mid-day.

The most unusual exception to the nocturnal habits shown by adult fox was male 344 who was found on the surface as often in daylight as he was at night. He was moving and hunting during these observations, not merely lounging around his den as others have observed adult fox doing (Morrell, 1972). We have no explanation for his unusual behavior.

Kit fox are primarily carnivorous. They are opportunistic as well and have been known to eat some insects but little vegetation (Laughrin, 1970; Egoscue, 1962; 1975; Morrell, 1972). In Utah principal food items were black-tailed jackrabbits, desert cottontails, *Sylvilagus audubonii*, and some kangaroo rats *Dipodomys ordii* and *D. microps* (Egoscue, 1962, 1975). In the San Joaquin Valley of California 80-90% of the material observed in 600 kit fox scats were kangaroo rats, *Dipodomys nitratoides, D. ingens* (Laughrin, 1970; Morrell, 1972). They have also been known to eat ground-dwelling birds, a few reptiles, insects and some vegetable material (Egoscue, 1956, 1962, 1975; Laughrin, 1970; Morrell, 1972).

Our limited information on prey items indicates that *V. m. macrotis* in Kern County subsist mainly on leporids and rodents, probably in proportions similar to those observed in Utah (Egoscue, 1962). The most unusual prey remains were those of a Roadrunner and a rattlesnake. Even in the dark either animal could be a formidable foe and we were surprised to find them in remains.

Results of our rodent trapping sessions to index prey populations showed that both the Rand and Tortoise areas had similar species composition and relative abundance of dominant rodents. Road surveys of jackrabbits also indicated

little difference in the availability of hares and rabbits. However, we still feel that these surveys failed to accurately show the higher densities of hares and rabbits that were found in the Rand Area, especially in areas adjacent to agricultural areas. When we were anxious to collect rabbits for bait we always drove to the Rand Area rather than waste time in the Tortoise Area.

The free water requirements of kit fox have not been determined. Because their diet is mainly protein, they would be operating at a water deficit unless they are capable of either excreting highly concentrated urine, or can obtain free water frequently. Egoscue (1956) found kit fox dens many kilometers from sources of free water and suggested that they may obtain adequate water from their prey. Egoscue did observe that kit fox ate snow, and captives readily drank water. Morrell (1972) reported that San Joaquin kit fox do not need a source of drinking water since they apparently obtain moisture from their prey, but he provided no evidence to support this conclusion. While monitoring bird guzzlers we did obtain evidence that fox were in the immediate vicinity of this free water source throughout one night. We can't say with certainty that the fox actually drank water as we were unable to see them in the dark. Physiological studies of kit fox are needed to characterize the water requirements of kit fox feeding on normal prey. It is probable that the bird guzzlers established by the California Dept. of Fish and Game in arid habitats that include kit fox, may also provide a necessary, or at least supplemental, source of free water for the fox as well.

Reproduction in kit fox on the Rand Area was similar to that described for other subspecies in Utah and California (Egoscue, 1956, 1962; Morrell, 1972). Adult males had palpable testes throughout the year. The most conspicuous change in their genitalia occurred in January when their penises were obviously enlarged, red in color, and often appeared to be extended from their sheaths.

Females were in estrus in December and January. Their vulva were slightly enlarged and moist, probably due to a vaginal secretion. Some of the vixens were also gaining weight in January which may have represented weight gains due to pregnancy. Females live-trapped in March and April were lactating, which suggests that pups were born in February or March.

In other studies, vixens began to search for natal dens in September and October. When one was selected, it was thoroughly cleaned and new tunnels or entrances were often dug (Egoscue, 1956, 1962; Morrell, 1972). Males joined the females in the natal dens in October and November, and breeding took place

between December and March (Egoscue, 1956). An average of 4 to 5 pups were born between February and March (Egoscue, 1956, 1962, 1975; Morrell, 1972).

Pups usually don't appear aboveground until they are at least one month old (Morrell, 1972). We first noted pups on the surface in May.

Kit fox are thought to be essentially monogamous, and may mate for life (Grinnell et al., 1937, Egoscue, 1962). However, Morrell (1972) observed that only one of seven mated pairs was paired during the next breeding season, and Egoscue (1962) recorded three cases of polygamy. During this study we observed four mated pairs: one pair in the Tortoise Area; three in the Rand Area. The former were dead within a month and yielded no further information. In the Rand Area one pair was together until mid-June when they apparently split up. At least they were never found together after that. The male was killed before mid-August. The female seemed to expand her range before she was finally re-trapped in January, 1979.

The other two pairs in the Rand Area were together throughout the study, including the second breeding season in 1978/1979.

The limited information gathered during this study, as well as the results of previous studies (Egoscue, 1962; Morrell, 1972) indicate that kit fox employ a flexible strategy as regards reproductive pairing. Some pairs may remain mated for more than one breeding season, while others may change partners frequently.

Published information indicates that kit fox do not breed their first year and tend to remain solitary (Morrell, 1972; Egoscue, 1975). We observed one male in January, 1979, who was adult in weight, yet showed no signs of reproductive activity. He had a small, flaccid, flesh-colored penis quite unlike those of known-age adults that were probably breeding. He may have been born during 1978.

The average age of adult populations in Utah was a consistent 2+ years, while the average maximum age attained was 5+ years. One male lived at least seven years (Egoscue, 1975). Approximately 40 to 50% of the resident foxes were lost to either mortality or emigration each year in Utah (Egoscue, 1962). Although our study was too short to provide us with longevity information, some of the data may serve as a useful index to this parameter. On the Rand Area seven of the fox were known to be alive for an average of 11 months (range 8-14). Five of the animals were still alive when the study was terminated. Since all of these animals were breeding adults in 1977/1978, we assume they were born during or before the 1975/1976 breeding season. This suggests that

they were at least three years old when the project was terminated.

By contrast, fox on the Tortoise Area were known to be alive for an average of 2.4 months. Ten of the animals were alive for one month or less, and only one male was active for at least nine months. The weight and breeding condition of the male indicated that he was probably born in 1976/1977, which would make him at least two years old when he was killed.

The data on longevity provided further evidence that the populations of kit fox on the Rand and Tortoise areas were not comparable. The relatively high turnover of adults in the Tortoise Area as compared with the stability of adults on the Rand Area, suggests that the Tortoise Area was not a suitable habitat for kit fox in 1977-1979.

The factors responsible for differences between the study areas were not obvious, but information on sources of mortality suggested tentative answers. In the Rand Area only two dead kit fox were retrieved. Both of these animals were shot. In the Tortoise Area 11 dead fox were recovered. Two adults were dug from their dens after they apparently died in cave-ins. Although we seldom consider the role of accidents in wild animal mortality, it certainly appeared that the headwalls of both dens collapsed, pinning the animals in chambers, although the remaining tunnels appeared to be clear and unaffected by the cave-ins. It is difficult not to speculate on the role that natural ground movements, such as earthquakes, and man-made shocks, such as bouncing of heavy ORV's above a den, might have in causing mortality due to cave-ins of kit fox dens.

Seven other kit fox were dug from their dens but they were not in collapsed tunnels or chambers. Several of the animals showed signs of acute malnutrition: no food in the gastrointestinal tract; no subcutaneous fat; no mesenteric fat. One of the animals also had a compound fracture of the right femur. Two of the dead fox were found on the surface: one had a crushed skull and tooth puncture marks; the other was malnourished, but had died due to thoracic trauma, probably caused by a coyote bite.

The two animals found dead aboveground in the Tortoise Area were probably killed by coyotes. Male 344 was found dead on 9 January 1979, just four days after he had been tracked to a new den. The base of his skull was crushed and showed tooth puncture marks. He had not been eaten, however.

Male 351A was first trapped and radio-collared on 8 January 1979. He was located in two dens on four occasions between 9-11 January. Between 22-23 January we were unable to locate or trap this animal. On 24 January we

concentrated our efforts on recovering radios from this fox and others still unaccounted for in the two study areas. At 1430 we stopped at den DT-21 above a large wash. We picked up radio signals on channel 07 which indicated that Male 351A was east-southeast of the hill. The strong signal indicated that the animal was close and may have been on the surface. One of us walked directly towards the source of the strongest signal while the other drove south and then east to cut the animal off at a point diagonal from the hill. The signal seemed to be moving south; it weakened and was no longer on the original bearing. The tracker had to make a 90° turn to keep up with the radio signal. After cresting a slight rise at 1500 hours he found the radio-collared fox lying on its side. The animal appeared to have died within a short time before we found him. His chest had been crushed and puncture wounds were found between two ribs. Teeth on a reference skull of a coyote fit the puncture wound width. The consulting pathologist concluded that the fox died from a dog or coyote bite. We concluded that he died of a coyote bite since no domestic dogs were ever observed in the area, and none were seen that day.

Coyotes are considered to be potential predators of kit fox (Goldman, 1930; Young and Jackson, 1951), and Seton (1937) offered the thesis that kit fox used dens to avoid confrontations with coyotes. However, kit fox remains have been found in only two of approximately 8,357 coyote stomachs examined (Sperry, 1941). Egoscue (1962) was unable to provide conclusive evidence that coyotes were, or were not, predators of kit fox. He did however, relate how a U. S. Fish and Wildlife Service employee observed a coyote digging at a fox den that was found to contain a small pup. Another coyote was observed stalking a fox family that was aboveground near their den.

The high proportion of fox on the Tortoise Area that showed signs of emaciation, and the lack of this condition in Rand Area fox strongly suggests that food supplies were more dependable in the latter area. Our surveys of rodents and leporids were not very quantitative since they were strictly indices. In spite of the similarity in numbers obtained from both areas, we still believe that food supplies, especially hares and rabbits, were greater in the Rand Area.

Egoscue (1975) concluded that kit fox populations in Utah responded to changes in the availability of black-tailed jackrabbits. Nonbreeding adult vixens were first observed during a decline in jackrabbit numbers. This was followed by a decline in the numbers of adults, and finally by smaller and fewer litters of fox. Fox were unable to sustain themselves on secondary prey such as kangaroo

rats or diurnal small mammals. As jackrabbit numbers increased the sizes of kit fox litters returned to normal.

Red fox also starve during food shortages rather than shift their territories to sites with more numerous prey (Scott and Klimstra, 1955). Morrell (1972) speculated that starvation was a factor limiting kit fox populations, and he further suggested that the total population may decline in years of low rodent populations. However, Egoscue (1975) points out that no published data show that kangaroo rat populations fluctuate drastically.

We can only state with certainty that most of the kit fox recovered dead in the Tortoise Area showed signs of starvation. We have no information on causal factors.

Many fox are killed by cars (Egoscue, 1962; Morrell, 1972); the automobile is thought to be the greatest cause of reported San Joaquin kit fox deaths (Morrell, 1975). Kit fox are also vulnerable to hunting, especially night-hunting for predators (Laughrin, 1970; Morrell, 1972, 1975). There has also been some concern that rodent control practices may threaten kit fox through secondary poisoning (Swick, 1973; Schitoskey, 1975). Of the above human impacts we observed only indiscriminate shooting as a source of mortality in the Rand Area.

The most conspicuous ectoparasites observed on kit fox were fleas. They were found throughout the year, but appeared to be most dense between December and April. They also seemed to be more dense on females than on males, especially during the pupping season. One species, *Pulex irritans*, was found on all fox and was the most numerous collected. Egoscue (1962) also found this to be the most common flea on kit fox in Utah. We also found *Echidnophaga gallinacea* and *Orchopeas leucopus* on a single fox. The former has been found on kit fox in Nevada and California (Hubbard, 1947; Beck and Allred, 1966; Morrell, 1972), although it is more commonly found on birds. The latter species is more commonly found on species of *Peromyscus* and *Reithrodontomys*, and our kit fox probably picked it up while eating a deer mouse or one of its cousins. This is the first time that *Orchopeas leucopus* has been reported on kit fox. Other fleas commonly found on kit fox include: *Thrassis bacchi gladiolis; T. aridus; Monopsyllus wagneri wagneri; Meringis parkeri; M. dipodomys* (Egoscue, 1962; Beck and Allred, 1966).

The only endoparasites we observed was a mass of unidentified tapeworms found in the small intestine of the male fox killed by a coyote. A new species of cestode, *Mesogyna hepatica*, was found in the liver of a kit fox (Voge, 1952).

Egoscue (1956) observed unidentified roundworms and tapeworm proglottids in kit fox feces.

One of the major goals of this project was to evaluate the possible impacts of ORV's on desert kit fox populations. We documented only one conclusively, the killing of kit fox by off-road enthusiasts in the Rand Area. There was limited evidence that a cycle race in October may have evicted a pair of fox denning in close proximity to the course.

Except for the above disturbances, kit fox populations in the Rand Area were more dense, appeared to breed more successfully, lived longer, and did not appear to suffer from malnutrition, as compared with fox populations in the Tortoise Preserve. The apparently benign impacts of ORV's and their users in the Rand Area may, however, be an artifact of our choice of "control" areas. If kit fox populations in the Tortoise Area were being subjected to severe natural stresses, such as low prey populations, that were not applied to the Rand populations, then our "control" was not adequate. The question of how ORV's impact kit fox will not be satisfactorily answered until a control population is found that matches the Rand population in all respects other than impacts due to ORV's.

CONCLUSIONS AND RECOMMENDATIONS

We were unable to document any significant, immediate impacts of ORV's or their users on kit fox populations in Kern County. Two fox were illegally shot, but this is not a unique practice of ORV users. Indiscriminate shooting has led to major closures of San Joaquin kit fox ranges to predator hunters. This conclusion is made with the caveats that: the "control" population may have been inadequate; this was a brief study that made no attempt to evaluate long-term impacts; and, finally, ORV stresses were not applied in an experimental manner.

Two possibly negative impacts should be studied in a more direct manner: triggering of cave-ins by ORV's passing over dens, especially natal dens; harassment of occupied dens by noise and vibrations of ORV's passing over them.

We obtained good circumstantial evidence that fox may die in den cave-ins. Can ORV's bouncing on the surface of a den trigger such a cave-in? Would a pair of adults be able to remove their pups from a damaged natal den? We recommend that field experiments be designed and implemented to answer these questions.

Most ORV activities take place during the day when kit fox are normally in their dens. Do the surface activities of ORV's disturb fox in their dens? Are the disturbances sufficient to cause fox to change their den sites or home ranges? We recommend that field experiments be designed and executed to apply measured ORV stresses on fox in their dens to determine the answers to these questions.

Measurements of home range size, hunting patterns, and dispersal were not adequately covered during this study, due mainly to a lack of equipment and personnel. Our contract limited us to one investigator for most field trips, and we had only one radio receiver. It was virtually impossible for us to triangulate on moving animals under these conditions. Future studies to determine movement patterns using radio telemetry should not be undertaken unless at least two investigators and two receivers can be funded.

We also recommend that all future radio-collars be equipped with an optional mortality signal. Since many radio locations are obtained during the day it is difficult to be certain when an animal is sleeping or dead. Furthermore, without the mortality signal, an investigator can't be sure that an animal is dead just because the animal isn't active on the surface at night. We had to wait

several days to accumulate evidence that an animal was dead, at which time decomposition had destroyed evidence of the cause of death.

One of the most significant findings was the role that malnutrition may play in the mortality of kit fox, especially during the late-winter when rodent prey may be less numerous. We urge that funding be provided to study sources of mortality further. This is an especially important goal since one biological endpoint used to assess impacts of ORV's and other environmental impacts is whether they contribute to increased mortality. We must know more about natural causes of mortality before we will be able to adequately assess the contributions of additional sources of mortality.

The results of this and other published studies suggest that natal dens, used exclusively by mated pairs, may be an important element in the critical habitat of the kit fox. It may be important to consider the importance of protecting these apparently ancestral den sites from additional destruction. A study of the long-term use and importance of natal dens should be funded. The study should include an investigation to determine whether human activities, heavy grazing, ORV's, etc., damage these older dens, and whether the fox can effectively restore the dens after a severe impact.

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Appendix 1. Kit fox trapping records. Each page contains the complete records of trapping and radio telemetry information for an individual fox from either the Rand or Desert Tortoise areas. Information on animal number, sex, location, weight, measurements of ear-from-notch, and standard measurements (dead animals only), are included for all animals. Trapping information includes: date of capture; specific location; pelage characteristics; reproductive condition; ectoparasite load; and behavior. Animals that were located by radio bearings have the following information listed for most observations: date; time; location; activities.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER:
Ear Tag: 267

SEX: Female

LOCATION: Rand Open Area
Kern County, California

WEIGHT: 2,050 g

E.F.N.: 81 mm

TRAPPING DATA:

1. 23 Jan. 1979; den RA-28; NE¼, SW¼, Sec. 19, T30S, R39E, 2,320 ft.; vulva open, wet; not visibly pregnant; mammae not prominent; numerous fleas; gray color, buffy-red sides; ran west.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER:
Ear Tag: 268

SEX: Female

LOCATION: Rand Open Area
Kern County, California

WEIGHT: 2,275 g

E.F.N.: 83 mm

TRAPPING DATA:

1. 23 Jan. 1979; near den RA-11; SW¼, SW¼, Sec. 17, T30S, R39E, 2,210 ft.; vulva open, wet; not visibly pregnant; mammae not prominent; gray color, buffy-red sides, back; ran west; wild!

KIT FOX TRAPPING RECORD

ANIMAL NUMBER:
Ear Tag: 269

SEX: Male

LOCATION: Rand Open Area
Kern County, California

WEIGHT: 1,900 g

E.F.N.: 88 mm

TRAPPING DATA:

1. 23 Jan. 1979; near den RA-1; SW¼, SW¼, Sec. 18, T30S, R39E, 2,030 ft.; testes scrotal; penis, red, swollen, everted; gray-buffy sides; dark muzzle; ran north.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER: Ear Tag: 270 SEX: Female LOCATION: Rand Open Area, Kern County, California

WEIGHT: 1,800 g E.F.N.: 84 mm

TRAPPING DATA:

1. 23 Jan. 1979; near den RA-16; SE¼, SE¼, Sec. 13, T30S, R38E, 1,980 ft.; vulva open, wet; not visibly pregnant; mammae not prominent; gray, light buffy sides; many fleas, ran into RA-16.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER: SEX: Female LOCATION: Rand Open Area
Ear Tag: 272 Kern County, California
Radio: 01 (102 g)

WEIGHT: 1,925 g (23 Jan. 1979) E.F.N.: 82 mm (16 Nov. 1977)
81 mm (23 Jan. 1979)

TRAPPING DATA:

1. 16 Nov. 1977; den RA-1; SW¼, SW¼, Sec. 18, T30S, R39E; light gray pelage; ran into den RA-1; collar yellow/orange.
2. 23 Jan. 1979; near RA-31. NW¼, SW¼, Sec. 19, T30S, R39E, 2120 ft, vulva open, wet; not visibly pregnant; mammae not prominent; few fleas; ran north. Radio #01 recovered.

RADIO FIXES:

1. 16 Nov. 1977 (p.m.) Located on surface due west of hill in Sec. 20, T30S, R39E. Distance unknown.
2. 17 Nov. 1977 (a.m.) In den RA-2.
3. 18 Nov. 1977 (a.m.) Located in den RA-2.
4. 13 March 1978 (day) Located in den RA-2.
5. 1 April 1978 (a.m.) Located in den RA-1 with animal #00.
6. 2 April 1978 (night) Located hunting on surface at base of Rand Mts. about 3 miles S.W. of den RA-1. Animal #00 (April 1 my notes) nearby.
7. 11 March 1978 (day) Located in RA-1.
8. 12 March 1978 (1:30 p.m.) In den RA-1.
9. 24 May 1978 (11:23 a.m.) In den RA-1 with #00.
10. " (9:20 p.m.) North of Bench Mark, possibly in den RA-1.
11. 25 May 1978 (6:48 a.m.) In den RA-12 with #00 and 2 pups (sighting)
12. " (12:45 p.m.) " " " "
13. 26 May 1978 (5:38 p.m.) " " " "
14. " (2:36 p.m.) " " " "
15. 8 July 1978 (1:48 p.m.) In den RA-16 with #00. New den.
16. 9 July 1978 (9:15 a.m.) " " "
17. 27 July 1978 (5:14 p.m.) In den RA-12 with #00.
18. " (8:07 p.m.) I followed #1 east from RA-12 about 0.4 miles.
19. 28 July 1978 (5:30 a.m.) In den RA-12 with #00.
20. 30 July 1978 (11:56 a.m.) " "
21. 18 August 1978 (3:31 p.m.) In den RA-24.
22. 20 August 1978 (3:39 p.m.) In new found den RA-26.
23. 26 Sept. 1978 (3:44 p.m.) In den RA-26 with #00.
24. 27 Sept. 1978 (8:01 a.m.) " " "
25. 3 Oct. 1978 (1:42 p.m.) In den RA-2 with #00.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER: Ear Tag: 273

SEX: Male

LOCATION: Rand Open Area
Kern County, California

WEIGHT: 2,000 g

E.F.N.: 79 mm

TRAPPING DATA:

1. 24 January 1979; den RA-32; NE¼, SE¼, Sec. 19, T30S, R39E; 2,340 ft.; scrotal testes; red, swollen penis; gray color, red back; light-colored muzzle; few fleas; ran west.
2. 25 January 1979; den RA-10; NE¼, NE¼, Sec. 19, T30S, R39E; 2,210 ft.; ran NW.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER Ear Tag: 275	SEX: Male	LOCATION: Rand Open Area Kern County, California
WEIGHT: 2,025 g	E.F.N.: 82 mm	

TRAPPING DATA:

1. 24 January 1979; wash near den RA-17; NE¼, NE¼, Sec. 19, T30S, R39E; 2,230 ft.; testes small; penis small, not swollen or red; gray color overall, red guard hairs. Ran south.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER: SEX: Male LOCATION: Rand Open Area
Ear Tag: 339 Kern County, California
Radio: 00 (103 g)

WEIGHT: 1,967 g (12 March 1978) E.F.N.: 81 mm (12 March 1978)
2,075 g (23 Jan. 1979) 88 mm (23 Jan. 1979)

TRAPPING DATA:

1. 12 March 1978; den RA-1; SW¼, SW¼, Sec. 18, T30S, R39E; buffy-gray pelage; lower left canine broken; few fleas.
2. 13 March 1978; den RA-1; radio collar O.K.; ran west upon release.
3. 23 Jan. 1979; den RA-31; NW¼, SW¼, Sec. 19, T30S, R39E, 2,160 ft.; gray and red-brown color; scrotal testes, penis swollen; missing lower left canine; ran north; radio #00 recovered.

RADIO FIXES:

1. 13 March 1978 (day) Located in den RA-3.
2. 1 April 1978 (a.m.) Located in den RA-1 with animal #01.
3. 1 April 1978 (night) Located on surface at base of Rand Mts. about 3 miles SW of den RA-1; animal #01 (April 1 in my notes) near.
4. 4 April 1978 (day) Located from ridge 3.75 miles SSW; probably in den RA-1.
5. 12 March 1978 (1:30 p.m.) In den RA-3.
6. 24 May 1978 (11:34 a.m.) In den RA-1 with #1.
7. " (9:30 p.m.) Due east of Bench Mark by RA-1.
8. 25 May 1978 (6:48 a.m.) In den RA-12 with #1 and pups (2) (observed).
9. " (12:45 p.m.) " " " " " "
10. 26 May 1978 (5:38 a.m.) " " " " "
11. " (2:36 p.m.) " " " " "
12. 8 July 1978 (1:48 p.m.) In den RA-16 with #1; I just located them in this new den.
13. 9 July 1978 (9:15 a.m.) " " "
14. 27 July 1978 (5:14 p.m.) In den RA-12 with #1.
15. " (8:02 p.m.) Left den.
16. 28 July 1978 (5:30 a.m.) In den RA-12 with #1.
17. 29 July 1978 (6:00 p.m.) From air, as I flew over lower Rand Area near RA-12.
18. 30 July 1978 (11:56 a.m.) In den RA-12 with #1.
19. 18 Aug. 1978 (3:07 p.m.) In den RA-23.
20. 19 Aug. 1978 (11:34 a.m.) " "
21. 20 Aug. 1978 (3:15 p.m.) In den RA-23.
22. 26 Sept. 1978 (3:44 p.m.) In den RA-26 with #1.
23. 27 Sept. 1978 (8:01 a.m.) " " "
24. 3 Oct. 1978 (1:42 p.m.) In den RA-2 with #1.
25. 17 Nov. 1978 (2:00 p.m.) In den RA-16.
26. 18 Nov. 1978 (1:16 p.m.) In den RA-16.
27. 21 Nov. 1978 (9:52 a.m.) In den RA-16.
28. 10 Jan. 1979 (12:43 p.m.) In den RA-31 (newly discovered).

KIT FOX TRAPPING RECORD

ANIMAL NUMBER: SEX: Female LOCATION: Rand Open Area
Ear Tag: 340 Kern County, California
Radio: 03 (no weight)

WEIGHT: 1,730 g (12 March 1978) E.F.N.: 84 mm (12 March 1978)

TRAPPING DATA:
1. 12 March 1978; den RA-9; NE¼, NE¼, Sec. 19, T30S, R39E; red-brown pelage; lactating; dense fleas; ran away; caught collar.

RADIO FIXES:
1. 12 March 1978 (day) Located in den RA-4.
2. 13 March 1978 (day) Located in den RA-6.
3. 1 April 1978 (a.m.) Located in den RA-6 with animal #04.
4. 4 April 1978 (day) Located from ridge 3.75 miles SSW, probably in den RA-6.
5. 24 May 1978 (1:00 p.m.) In den RA-6 with #4.
6. " (8:25 p.m.) " " "
7. 25 May 1978 (7:35 a.m.) " " "
8. 26 May 1978 (2:08 p.m.) " " "
9. 13 June 1978 (12:05 p.m.) In den RA-13 with #4.
10. 14 June 1978 (8:30 a.m.) " " "
11. 8 July 1978 (3:20 p.m.) In den RA-17 with #4; new den site.
12. 8 July 1978 (9:30 p.m.) I received his signal north of den RA-17 and could not receive him at 9:35.
13. 9 July 1978 (5:30 a.m.) In den RA-17 with #4.
14. 27 July 1978 (4:37 p.m.) In den RA-17 with #4.
15. 29 July 1978 (6:00 p.m.) From air as I flew over RA-17.
16. 30 July 1978 (11:50 a.m.) In den RA-17 with #4.
17. 18 Aug. 1978 (3:01 p.m.) In den RA-6 with #4.
18. 19 Aug. 1978 (5:50 a.m.) In den RA-6 with #4.
19. 20 Aug. 1978 (3:50 p.m.) " " "
20. 26 Sept. 1978 (1:44 p.m.) " " "
21. 27 Sept. 1978 (7:30 a.m.) " " "
22. 3 Oct. 1978 (12:34 p.m.) In den RA-27 with #4 (newly found den).
23. 4 Oct. 1978 (11:48 a.m.) In den RA-13.
24. 17 Nov. 1978 (1:16 p.m.) In den RA-13 with #4.
25. 18 Nov. 1978 (12:46 p.m.) " " "
26. 21 Nov. 1978 (10:25 a.m.) " " "
27. 22 Nov. 1978 (2:09 p.m.) " " "
28. 27 Dec. 1978 (2:36 p.m.) In den RA-28 (newly discovered den).
29. 10 Jan. 1979 (11:55 a.m.) In den RA-30 (newly discovered).

KIT FOX TRAPPING RECORD

ANIMAL NUMBER: SEX: Male LOCATION: Rand Open Area
Ear Tag: 341 Kern County, California
Radio: 02 (101 g)

WEIGHT: 1,784 g (12 March 1978) E.F.N.: 82 mm (16 Nov. 1977)
81 mm (12 March 1978)

TRAPPING DATA:

1. 16 Nov. 1977: den RA-4; SW¼, NE¼, Sec. 19, T30S, R39E; red-brown and gray pelage; ran into den RA-4.
2. 12 March 1978; den RA-10; NE¼, NE¼, Sec. 19, T30S, R39E; ran away from capture site.

RADIO FIXES:

1. 16 Nov. 1977 (p.m.) Located on surface due north of hill in Sec. 20, T30S, R39E, distance unknown.
2. 17 Nov. 1977 (a.m.) Located in den RA-11.
3. 18 Nov. 1977 (a.m.) Located in den RA-11.
4. 11 March 1978 (a.m.) Located in den RA-10.
5. 1 April 1978 (a.m.) Located in den RA-10 with animal #05.
6. 12 March 1978 (p.m.) Located in den RA-9.
7. 13 March 1978 (10:03 a.m.) In den RA-10.
8. 24 May 1978 (1:29 p.m.) In den RA-11 with #5.
9. 25 May 1978 (12:45 p.m.) " " "
10. 26 May 1978 (7:50 a.m.) In den RA-11 with #5 and a pup (uncollared kit fox observed).
11. 13 June 1978 (12:39 p.m.) " " " either 2 or 5 was above ground.
12. " (10:55 p.m.) Back in den RA-11.
13. 14 June 1978 (3:08 a.m.) In den RA-11; he was gone at 2:12 a.m.
14. " (5:46 a.m.) In den RA-11 with #5.
15. 8 July 1978 (3:52 p.m.) In den RA-18; new den site near RA-11.
16. 9 July 1978 (7:40 a.m.) Followed #2 on foot around RA-11/18 and lost him.
17. " (8:30 a.m.) " " " " RA-9/10 " "
18. " (9:44 a.m.) " " southwest from RA-11/18 and lost him.
19. " (10:40 a.m.) In den RA-9.
20. 27 July 1978 (7:04 p.m.) In a new den, RA-21.
21. 28 July 1978 (10:55 a.m.) I followed #2 from little ridge 0.3 miles west of RA-11 south 0.25 miles, then east and northeast past RA-11 before losing him.
22. 18 Aug. 1978 (4:28 p.m.) Found dead 150 m north of grey knob near RA-11; SW¼, SW¼, Sec. 17, T30S, R39E.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER: Ear Tag: 342 Radio: 04 (103 g)	SEX: Male	LOCATION: Rand Open Area Kern County, California

WEIGHT: 1,727 g (12 March 1978) E.F.N. 83 mm (12 March, 1978)

TRAPPING DATA:

1. 12 March 1978; den RA-4, SW¼, NE¼, Sec. 19, T30S, R39E; red-brown pelage; moderate flea density; ran away on release.

RADIO FIXES:

1. 13 March 1978 (day) Located in den RA-7.
2. 1 April 1978 (day) Located in den RA-6 with animal #03.
3. 4 April 1978 (day) Located from ridge 3.75 miles SSW, probably in den RA-6.
4. 12 March 1978 (1:00 p.m.) In den RA-5.
5. 24 May 1978 (1:00 p.m.) In den RA-6 with #3.
6. " (8:25 p.m.) " " "
7. 25 May 1978 (7:35 a.m.) " " "
8. 26 May 1978 (2:08 p.m.) " " "
9. 13 June 1978 (12:15 p.m.) In den RA-13 with #3.
10. 14 June 1978 (8:30 a.m.) " " "
11. 8 July 1978 (3:20 p.m.) In den RA-17 with #3; new den site.
12. " (8:30 p.m.) #4's signal came in north of den RA-17.
13. 9 July 1978 (5:30 a.m.) In den RA-17 with #3.
14. 27 July 1978 (4:37 p.m.) In den RA-17 with #3.
15. 29 July 1978 (6:00 p.m.) From air as I flew over RA-17.
16. " (9:47 p.m.) In vicinity of guzzler 2 miles east of RA-17.
17. " (11:00 p.m.) " " " " " "
18. 30 July 1978 (11:50 a.m.) In den RA-17 with #3.
19. 18 Aug. 1978 (3:07 p.m.) In den RA-6 with #3.
20. 19 Aug. 1978 (5:50 a.m.) " " "
21. 20 Aug. 1978 (3:50 p.m.) " " "
22. 26 Sept. 1978 (1:44 p.m.) " " "
23. 27 Sept. 1978 (7:30 a.m.) " " "
24. 3 Oct. 1978 (1:06 p.m.) In den RA-27 with #3 (newly discovered den).
25. 4 Oct. 1978 (11:48 a.m.) In den RA-27.
26. 17 Nov. 1978 (1:16 p.m.) In den RA-13 with #3.
27. 18 Nov. 1978 (12:46 p.m.) In den RA-13 with #3.
28. 21 Nov. 1978 (10:25 a.m.) In den RA-13 with #3.
29. 22 Nov. 1978 (2:09 p.m.) In den RA-13 with #3.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER SEX: Female LOCATION: Rand Open Area
Ear Tag: 343 (Lost) Kern County, California
274
Radio: 05 (102 g)

WEIGHT: 1,828 g, 13 March 1978 E.F.N.: 87 mm, 13 March 1978
2,450 g, 24 Jan. 1979 88 mm, 24 Jan. 1979

TRAPPING DATA:

1. 13 March 1978; den RA-9; NE¼, NE¼, Sec. 19, T30S, R39E; lactating; left ear torn; tag in right ear; heavy fleas.
2. 24 January 1979; 140 m north of den RA-32; NE¼, SE¼, Sec. 19, T30S, R39E; 2,340 ft.; vulva open, wet; not visibly pregnant; mammae not prominent; many fleas; both ears notched where lost tags would be; ran north; radio #05 recovered.
3. 25 January 1979; den RA-6; SE¼, NE¼, Sec. 19, T30S, R39E; 2,260 ft.; ran west.

RADIO FIXES:

1. 1 April 1978; den RA-10; NE¼, NE¼, Sec. 19, T30S, R39E; in den with #02 male.
2. 4 April 1978; probably den RA-10; radio fix from ridge several miles south (3.75 miles SSW).
3. 24 May 1978 (1:29 p.m.) In den RA-11 with #2.
4. 25 May 1978 (12.45 p.m.) " " "
5. 26 May 2978 (7:50 a.m.) In den RA-11 with #2 and an uncollared fox I saw.
6. 13 June 1978 (12:39 p.m.) " " " " either 2 or 5 was above ground.
7. " (8:29 p.m.) Out hunting southwest of RA-11.
8. 14 June 1978 (5:46 a.m.) In den RA-11 with #2; she was out at 2:17 a.m. and 3:08 a.m.
9. 8 July 1978 (6:00 p.m.) In den RA-19; new den site.
10. 9 July 1978 (7:59 a.m.) In den RA-20; new den.
11. 27 July 1978 (6:28 p.m.) In a new den RA-22 (2 entrances, 175 m NE of RA-9).
12. 28 July 1978 (9:54 a.m.) In den RA-22.
13. 29 July 1978 (6:00 p.m.) From air as I flew over RA-9, 22.
14. 30 July 1978 (11:56 a.m.) In den RA-22.
15. 20 Aug. 1978 (3:03 p.m.) In den RA-25.
16. 26 Sept. 1978 (3:44 p.m.) In den RA-11.
17. 27 Sept. 1978 (8:19 a.m.) " "
18. 3 Oct. 1978 (2:03 p.m.) " "
19. 4 Oct. 1978 (12:29 p.m.) " "
20. 17 Nov. 1978 (2:00 p.m.) In den RA-11.
21. 18 Nov. 1978 (1:00 p.m.) " "
22. 21 Nov. 1978 (6:15 a.m.) Near RA-11.
23. 21 Nov. 1978 (9:15 a.m.) In den RA-11.
24. 10 Jan. 1979 (12:32 p.m.) In den RA-17.
25. 23 Jan. 1979 (1:45 p.m.) In new den RA-32.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER:
Ear Tag: 595

SEX: Female

LOCATION: Rand Open Area
Kern County, California

WEIGHT: 2,025 g

E.F.N.: 82 mm

TRAPPING DATA:

1. 25 Jan. 1979; den RA-32; NE¼, SE¼, Sec. 19, T30S, R39E, 2,340 ft; vulva open, wet; not visibly pregnant; mammae not prominent; few fleas; ran NW.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER Ear Tag: 336 Radio: 06 (101 g)	SEX: Female	LOCATION: Desert Tortoise Area Kern County, California

WEIGHT: 1,624 g (12 March 1978) E.F.N.: 81 mm (12 March 1978)

TRAPPING DATA:
1. 12 March 1978; den DT-7; SW¼, SW¼, Sec. 15, T31S, R38E; red-brown pelage; lactating; fleas; ran away on release.

RADIO FIXES:
1. 12 March 1978 (day) Located in den DT-8 with animal #07.
2. 13 March 1978 (a.m.) Located in den DT-8 with animal #07.
3. 14 March 1978 (a.m.) " " " " "
4. 1 April 1978 (5:35 p.m.) In den DT-15.
5. 2 April 1978 (day) Located alone in den DT-15.
6. 3 April 1978 (day) Located alone in den DT-15.
7. 4 April 1978 (day) Located in den DT-15.
8. 6 May 1978 (6:56 a.m.) In den DT-15.
9. 24 May 1978 (8:00 a.m.) " "
10. 26 May 1978 (4:32 a.m.) " "
11. 12 June 1978 (7:53 a.m.) " "
12. 13 June 1978 (5:10 a.m.) " "
13. 29 July 1978 (5:15 p.m.) From air as I flew over DT-15.
14. 20 Aug. 1978 (7:02 p.m.) Dan Delaney and I dug up #6 from DT-15, SW¼, NE¼, Sec. 21, T31S, R38E.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER:
Ear Tag: 337
Radio: 07 (98 g)

SEX: Male

LOCATION: Desert Tortoise Area
Kern County, California

WEIGHT: 1,907 g (12 March 1978) E.F.N.: 81 mm (12 March 1978)

TRAPPING DATA:
1. 12 March 1978; den DT-9; NE¼, NW¼, Sec. 22, T31S, R38E; buffy gray pelage; few fleas; testes palpable; ran away upon release.

RADIO FIXES:
1. 12 March 1978 (day) Located in den DT-8 with animal #06.
2. 13 March 1978 (a.m.) Located in den DT-8 with animal #06.
3. 14 March 1978 (a.m.) " " " " " "
4. 1 April 1978 (p.m. sunset) South of our access to DTP near middle x-road; he was moving.
5. 2 April 1978 (day) Located alone in den DT-16.
6. 3 April 1978 (day) Located alone in den DT-8.
7. 4 April 1978 (day) " " " "
8. 6 May 1978 (8:05 a.m.) In den DT-19.
9. 26 May 1978 (4:27 p.m.) " "
10. 12 June 1978 (7:43 p.m.) " "
11. 13 June 1978 (4:42 a.m.) " "
12. 15 June 1978 (3:13 p.m.) " " In or near den all night.
13. 16 June 1978 (6:22 a.m.) " "
14. 7 July 1978 (7:23 p.m.) " "
15. 29 July 1978 (5:15 p.m.) From air as I flew over DT-19.
16. 21 Aug. 1978 (8:47 p.m.) Dan Delaney and I removed his remains from DT-19; SE¼, SW¼, Sec. 16, T31S, R38E.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER: SEX: Male LOCATION: Desert Tortoise Area
Kern County, California
Ear Tag: 338
Radio: 08 (98 g)

WEIGHT: 2,171 g (12 March 1978) E.F.N.: 83 mm (12 March 1978)

TRAPPING DATA:
1. 12 March 1978; den DT-11; NW¼, NE¼, Sec. 22, T31S, R38E; buffy-gray pelage; testes palpable; few fleas; right eye ruptured; ran away.

RADIO FIXES:
1. 12 March 1978 (day) Located in den DT-12.
2. 13 March 1978 (a.m.) Located in den DT-12.
3. 14 March 1978 (a.m.) Located in den DT-9.
4. 1 April 1978 (5:35 p.m.) In den DT-9.
5. 3 April 1978 (day) Located in den DT-9.
6. 4 April 1978 (day) " " "
7. 5 May 1978 (4:34 p.m.) In den DT-9.
8. 6 May 1978 (6:56 a.m.) " "

KIT FOX TRAPPING RECORD

ANIMAL NUMBER: SEX: Male LOCATION: Desert Tortoise Area
Ear Tag: 344
Kern County, California
Radio: 09 (105 g)

WEIGHT: 1,545 g (2 April 1978) E.F.N.: 82 mm (2 April 1978)

TRAPPING DATA:

1. 2 April 1978; den DT-1; SE¼, SW¼, Sec. 18, T31S, R38E; gray-brown pelage; testes palpable; scar on right foreleg; ran away upon release.

RADIO FIXES:

1. 2 April 1978 (day) Animal stayed on surface for several hours, moving around in area of den DT-1.
2. 3 April 1978 (day) Located in den RA-18. Located later in day from ridge top NW of area.
3. 4 April 1978 (day) Located in den RA-18.
4. 5 May 1978 (2:55 p.m.) Out of den, about 500 m north of DT-18.
5. 5 May 1978 (8:16 p.m.) On the move southeast of position at 2:55 p.m.
6. 6 May 1978 (9:05 a.m.) Out of den 150 m west of Neuralia 0.2 miles east of turnoff to D.T.P.
7. " (10:30 a.m.) Same area as at 9:05 a.m.
8. " (1:35 p.m.) Still above ground about 200 m south of 9:05 location.
9. 20 Aug. 1978 (11:56 a.m.) In den DT-21 (new found den).
10. 21 Aug. 1978 (6:54 a.m.) Near DT-21 tracked to 0.5 miles west of den.
11. 3 Oct. 1978 (9:36 a.m.) In den DT-26 (newly discovered).
12. 5 Oct. 1978 (8:20 a.m.) " "
13. 9 Jan. 1979 (2:24 p.m.) Found him dead 50 yards south of main D.T.P. road (Corral Road) ¼ mile west of large drainage from California City; NW¼, NE¼, Sec. 24, T31S, R37E; skull appears to be crushed.

KIT FOX TRAPPING RECORD

MAL NUMBER:
Ear Tag: 345
Radio: 06

SEX: Female

LOCATION: Desert Tortoise Area
Kern County, CA.

WEIGHT: 1,815 g (27 Dec. 1978)
1,400 g (26 Jan. 1979)

E.F.N.: 77 mm (27 Dec. 1978)
79 mm (26 Jan. 1979)

TL: 750 mm (26 Jan. 1979)
T: 295 mm "
HF: 122 mm "

TRAPPING DATA:

1. 27 Dec. 1978; den DT-23; SE¼, NE¼, Sec. 20, T31S, R38E Castle Butte quad; gray with red sides; not visibly pregnant; mammae not prominent; went into den DT-23; numerous fleas and mites; 2,400 ft. gradual W-facing slope, Larrea-Ambrosia community; 7.25 miles NNE California City.

RADIO FIXES:

1. 27 Dec. 1978 (9:39 a.m.) In den DT-23.
2. " (7:10 p.m.) Around vicinity of "skull" intersection (1 mile south of mid X-road and main D.T.P. road).
3. 28 Dec. 1978 (11:09 p.m.) In den DT-16.
4. 29 Dec. 1978 (11:57 a.m.) In den DT-16 with #3.6.
5. " (3:21 p.m.) Can be received 1.25 miles south of DT-16 with omni-antenna.
6. 23 Jan. 1979 (2:00 p.m.) Radio picked up NE Rand Open Area at base of El Paso mountains; located there 3-4 times in next hour from higher hills, not from car on level ground.

25 Jan. 1979 (9:30 a.m.) Located by air in den between Garlock and Johannsberg roads, about 7 miles NE of Rand Area, 16-17 miles NE of capture site.

8. 25 Jan. 1979 (1:45 p.m.) Located in new den RA-33.
9. 25 Jan. 1979 (9:30 p.m.) Located in new den RA-33, no movement.
10. 26 Jan. 1979 (10:00 a.m.) Recovered dead from den RA-33; broken right femur; no food in G-I tract; no mesenteric fat; fleas still alive.

Appendix 6. Maps of kit fox dens located during the study. The appended U. S. G. S. maps have been spotted with the approximate locations and code numbers for all kit fox dens, whether active or inactive, located during this study. Their locations, elevations, and characteristics are further documented in tables 2 and 3. Note: maps are attached to the master draft final report only.

KIT FOX TRAPPING RECORD

MAL NUMBER:
Ear Tag: 346
Radio: 02

SEX: Female

LOCATION: Desert Tortoise Area
Kern County, CA.

WEIGHT: 1,945 g (28 Dec. 1978)
2,675 g (25 Jan. 1979)

E.F.N.: 82 (28 Dec. 1978)
83 (25 Jan. 1979)

TL: 790 mm (25 Jan. 1979)
T: 300 mm "
HF: 127 mm "

TRAPPING DATA:

1. 28 Dec. 1978; road intersection NW¼, NW¼, Sec. 32, T31S, R38E; Castle Butte Quad.; 2,310 ft.; gray, some red sides; not visibly pregnant; not prominent mammae; headed east upon release; gradual W-facing slope; *Larrea-Ambrosia* community; 5.5 miles NNE California City.

RADIO FIXES:

1. 28 Dec. 1978 (3:35 p.m.) In den DT-29 (newly discovered).
2. 28 Dec. 1978 (10:14 p.m.) South of DT-22 from DT-22.
3. 3 Jan. 1979 (2:47 p.m.) In new den DT-30.
4. 8 Jan. 1979 (10:16 a.m.) In den DT-30.
5. " (5:55 p.m.) East of DT-30.
6. 9 Jan. 1979 (8:11 a.m.) In den DT-30.
7. 10 Jan. 1979 (8:46 a.m.) In den DT-30 with #7.
8. 11 Jan. 1979 (4:32 a.m.) We pick up #2 near Philips and "large wash" and followed her until 6:00 a.m. when she got back to DT-30 with #7.

22 Jan. 1979 (8:00 p.m.) In den DT-31, not moving.
23 Jan. 1979 (7:30 a.m.) In den DT-31, "

11. 23 Jan. 1979 (7:15 p.m.) " " "
12. 24 Jan. 1979 (6:15 a.m.) " " "
13. 25 Jan. 1979 (6:45 a.m.) " " "
14. 25 Jan. 1979 (4:00 p.m.) Recovered dead from Den DT-31.

KIT FOX TRAPPING RECORD

MAL NUMBER: SEX: Female LOCATION: Desert Tortoise Area
Ear Tag: 347 Kern County, CA.
Radio: 07

WEIGHT: 1,716 g (28 Dec. 1978) E.F.N.: 81 mm (28 Dec. 1978) TL: 775 mm (8 Jan. 1979)
1,250 g (8 Jan. 1979) 79 mm (8 Jan. 1979) T: 311 mm "
HF: 127 mm "

TRAPPING DATA:

1. 28 Dec. 1978; wash area; SW¼, NE¼, Sec. 29, T31S, R38E; Castle Butte Quad.; 2,360 ft.; gray with red sides; bloody vagina; NVP, NP. Left eye reddish, glazed, old injury? Excited; ran down road north, then west 6.25 miles NNE California City; W-facing slope, *Larrea*-*Ambrosia* community.

RADIO FIXES:

1. 28 Dec. 1978 (2:35 p.m.) In den DT-28 (newly discovered).
2. 8 Jan. 1979 (10:16 a.m.) Dead near den DT-31 (new den); SE¼, SW¼, T31S, R37E.

KIT FOX TRAPPING RECORD

MAL NUMBER:
Ear Tag: 348
Radio: 03.6

SEX: Male

LOCATION: Desert Tortoise Area
Kern County, CA.

WEIGHT: 2,277 g (28 Dec. 1978)
1,750 g (24 Jan. 1979)

E.F.N.: 82 mm (28 Dec. 1978)
82 mm (24 Jan. 1979)

TL: 800 mm (24 Jan. 1979)
T: 330 mm "
HF: 128 mm "

TRAPPING DATA:

1. 28 Dec. 1978; den DT-23; SE¼, NE¼, Sec. 20, T31S, R38E, Castle Butte Quad.; 2,400 ft.; gray, red sides; testes palpable; walked into den DT-23; 7.25 miles NNE California City; gradual W-facing slope; Larrea-Ambrosia community.

RADIO FIXES:

1. 28 Dec. 1978 (1:16 p.m.) In den DT-23.
2. 29 Dec. 1978 (11:57 a.m.) In den DT-16 with #06.
3. " (3:21 p.m.) Can be heard 1.25 miles south of DT-16 (he is in den).
4. 3 Jan. 1979 (5:12 p.m.) West of DT-15 from DT-15.
5. 7 Jan. 1979 (7:49 p.m.) West around DT-23. We followed him until 11:12 p.m. to bench mark on main road.
6. 8 Jan. 1979 (9:41 a.m.) In den DT-23.
7. 9 Jan. 1979 (4:37 p.m.) " "
8. " (6:13 p.m.) North of DT-23.
" (7:47 p.m.) Between DT-23 and "skull" intersection (1 mile south of mid X-road and Corral Road intersection).
10. 24 Jan. 1979 (1:15 p.m.) Located dead in entrance to new den DT-34. Radio #3.6 recovered. Tissues good; fleas still on animal; no fat; no food in G-I tract; diarrhea at anus.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER:
Ear Tag: 349
Radio: 11 (101 g)

SEX: Male

LOCATION: Desert Tortoise Area
Kern County, California

WEIGHT: 2,459 g

E.F.N.: 86 mm (8 Jan. 1979)

TRAPPING DATA:

1. 8 Jan. 1979; den DT-30, SE¼, SW¼, Sec. 24, T31S, R37E; gray color, excited, ripped the bait; fleas numerous.

RADIO FIXES:

1. 8 Jan. 1979 (3:20 p.m.) He is south of DT-30.
2. " (5:55 p.m.) " " "
3. 9 Jan. 1979 (2:06 p.m.) In den DT-33 (newly discovered).
4. 10 Jan. 1979 (8:46 a.m.) In den DT-33.
5. " (5:48 p.m.) Vicinity of DT-33.

KIT FOX TRAPPING RECORD

MAL NUMBER:
Ear Tag: 350
Radio: 12

SEX: Male

LOCATION: Desert Tortoise Area
Kern County, CA.

WEIGHT: 1,729 g (8 Jan. 1979)
1,500 g (25 Jan. 1979)

E.F.N.: 87 mm (8 Jan. 1979)
87 mm (25 Jan. 1979)

TL: 780 mm (25 Jan. 1979)
T: 300 mm "
HF: 126 mm "

TRAPPING DATA:

1. 8 Jan. 1979; DT-31, SE¼, SW¼, Sec. 24, T31S, R37E; headed northeast toward DT-31 and 20 minutes later walked up to Bronco and smelled bait in traps and then we gave him some jackrabbit.

RADIO FIXES:

1.	9 Jan. 1979	(8:18 a.m.)	In den DT-32 (newly discovered).
2.	"	(10:26 p.m.)	" "
3.	10 Jan. 1979	(8:46 a.m.)	In den DT-32.
4.	"	(5:44 p.m.)	" "
5.	22 Jan. 1979	(8:00 p.m.)	In den DT-33.
6.	23 Jan. 1979	(7:30 a.m.)	In den DT-33, no movement.
7.	23 Jan. 1979	(7:15 p.m.)	" " dead?
8.	24 Jan. 1979	(6:15 a.m.)	" " "
9.	25 Jan. 1979	(6:45 a.m.)	" "
10.	25 Jan. 1979	(3:00 p.m.)	Recovered dead in den DT-33.

KIT FOX TRAPPING RECORD

[illegible]AL NUMBER: 351A* Radio: 07	SEX: Male	LOCATION: Desert Tortoise Area Kern County, CA.

WEIGHT: 2,240 g (8 Jan. 1979)	E.F.N.: 85 mm (8 Jan. 1979)	TL: 810 mm (24 Jan. 1979)
1,575 g (24 Jan. 1979)	88 mm (25 Jan. 1979)	T: 330 mm "
		HF: 128 mm "

TRAPPING DATA:

1. 8 Jan. 1979; DT-30, SE¼, SW¼, Sec. 24, T31S, R37E; headed south of DT-30 upon release.

RADIO FIXES:

1. 9 Jan. 1979 (8:11 a.m.) In den DT-31.
2. 10 Jan. 1979 (8:46 a.m.) In den DT-30 with #2.
3. 11 Jan. 1979 (4:06 a.m.) In den DT-30.
4. " (6:00 a.m.) In den DT-30 with #2.
5. 24 Jan. 1979 (3:00 p.m.) Located ½ mile SE of den DT-21. Dead on surface. Radio 07 recovered. Diarrhea around anus. Still warm and fresh. Sent to Sacramento, Ca. Fish and Game Lab. Probably killed by coyote; also malnourished.

---

*This is an assigned number; no ear tag was applied to this animal.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER: SEX: Female LOCATION: Desert Tortoise Area
352A* Kern County, California
Radio: 11 (101 g)

WEIGHT: 1,990 g (27 Sept. 1978) E.F.N.: No measurement

TRAPPING DATA:

1. 27 Sept. 1978; den DT-25; NE¼, NW¼, Sec. 20, T31S, R38E; gray color, few fleas.

RADIO FIXES:

1.	27 Sept. 1978	(3:28 p.m.)	In den DT-23.
2.	"	(7:15 p.m.)	About 1/3 mile south of DT-23, then east.
3.	28 Sept. 1978	(7:15 a.m.)	About 300 meters east of DT-23, then westerly.
4.	"	(7:45 a.m.)	In den DT-23.
5.	3 Oct. 1978	(6:25 a.m.)	In den DT-24 (first time den was located).
6.	4 Oct. 1978	(6:56 a.m.)	In den DT-24.
7.	18 Oct. 1978	(3:45 p.m.)	In den DT-27 (just discovered).
8.	21 Nov. 1978	(4:13 p.m.)	In den DT-27 (stayed in den all night).
9.	23 Nov. 1978	(7:49 a.m.)	In den DT-27.
10.	26 Dec. 1978	(3:51 p.m.)	"

11. 3 Jan. 1979; Mike and I dug up #11 in DT-27 four feet underground; NE¼, SW¼, Sec. 29, T31S, R38E.

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*This is an assigned number; no ear tag was applied to this animal.

KIT FOX TRAPPING RECORD

ANIMAL NUMBER:
353A*
Radio: 12

SEX: Male

LOCATION: Desert Tortoise Area
Kern County, California

WEIGHT: 2,710 g

E.F.N.: No measurement

TRAPPING DATA:

1. 27 Sept. 1978; den DT-3; SW¼, SW¼, Sec. 17, T31S, R38E; male, palpable testes; gray color.

RADIO FIXES:

1. 27 Sept. 1978 (2:10 p.m.) In den DT-22.
2. 28 Sept. 1978 (8:36 a.m.) In den DT-22.
3. 2 Oct. 1978 (7:50 p.m.) Around vicinity of DT-3.
4. 3 Oct. 1978 (8:42 a.m.) In den DT-22.
5. 4 Oct. 1978 (9:30 a.m.) In den DT-22.
6. 17 Nov. 1978 (5:00 p.m.) " "
7. 18 Nov. 1978 (6:35 a.m.) " "
8. 21 Nov. 1978 (2:20 p.m.) " "
9. 28 Dec. 1978 (5:18 p.m.) In den DT-22. #12 was in den all night; 28-29 Dec.
10. 29 Dec. 1978 (11:09 p.m.) " "
11. 30 Dec. 1978 (6:24 a.m.) " "
12. 2 Jan. 1979; In den DT-22.
13. 3 Jan. 1979; We dug #12 up. He was dead in DT-22 three and one-half feet underground; NW¼, NW¼, Sec. 19, T31S, R38E.

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*This is an assigned number; no ear tag was applied to this animal.

Appendix 2. Summary of field trips. This appendix consists of Table 14, a summary of field trip dates, number of investigators making the trip, and the approximate proportion of time spent in the two study areas.

Table 14. Summary of field trip dates, number of investigators, and approximate proportion of time spent in the two study areas, Kern County, California, 1977-1979.

Dates	Number of Investigators	Proportion of Time Spent Rand Area	Tortoise Area
14-18 November, 1977	4	.7	.3
10-14 March, 1978	2	.3	.7
31 March-4 April	2	.2	.8
5-6 May	1		1.0
23-26 May	1	.7	.3
12-16 June	1	.3	.7
7-9 July	1	.5	.5
27-30 July	1	.7	.3
18-21 August	2	.7	.3
25-28 September	2	.2	.8
2-5 October	1	.2	.8
17-19 November	1	.5	.5
20-23 November	2	.5	.5
26-30 December	2	.1	.9
2-4 January, 1979	2		1.0
7-11 January	2	.4	.6
22-26 January	2	.7	.3
Total		.4	.6

Appendix 3. Pathology report. The freshly killed carcass of fox 344 was shipped to the Wildlife Investigations Laboratory, Wildlife Management Branch, California Department of Fish and Game, Sacramento. The complete laboratory report is appended.

THE RESOURCES AGENCY OF SOUTHERN CALIFORNIA
DEPARTMENT OF FISH AND GAME

LABORATORY REPORT

January 26, 1979

No. 56-79

Date Received 1/25/79

Collector Dr. Thomas O'Farrell
Gordon Gould

Address

Animal Desert Kit Fox, adult male

Remarks This animal was picked up near the Desert Tortoise Reserve north of California City shortly after it died on 1/24/79.

Specimen Whole, fresh

RESULTS OF EXAMINATION

Gross Necropsy:

Many fleas were present in the pelage. The animal was quite thin with no subcutaneous, omental, perirenal, or cardiac fat. Serous atrophy of cardiac fat was present; no marrow fat was evident grossly or on marrow impression smears. A pair of puncture wounds behind the eighth and eleventh ribs on the right side and 4 fractured ribs with attendant muscle hemorrhage on the left side was present. The lung lobes on both sides were lacerated and contained blood. Clotted blood was present in the thorax, the stomach contained bone fragments and hair. The anterior three fourths of the small intestine contained a few hairs, mucus, and a mass of tapeworms. The liver appeared grossly normal, on cross section dilated bile ducts containing small wormlike structures were evident. Wet mounts revealed segmented worms with scolex and sucker disked rostellum. Kidney, bladder, reproductive organs, spleen, lymph nodes, large intestine, and brain appeared normal.

Diagnosis:

Thoracic trauma, probably dog or coyote bite. Pulmonary laceration and hemorrhage. Emaciation and intestinal and hepatic cestodes (tapeworms).

WILDLIFE INVESTIGATIONS LABORATORY
WILDLIFE MANAGEMENT BRANCH

By David Jessup DVM
David A. Jessup, DVM

Comments: The emaciated condition of this animal is probably the result of comparatively high parasite loads at a time of the year when food scarcity is a problem. The nature of the bite wounds in the chest would suggest a coyote or small dog. Pulmonary hemorrhage and collapse are the immediate cause of death.

Appendix 4. Identification of fleas. Vials of fleas collected from almost every kit fox trapped were submitted for identification to Mr. Harold Egoscue. His letter with identifications and annotated information is appended. Other vials are being shipped to him for identification and will be reported on when they have been examined.

National Zoological Park·Smithsonian Institution·Washington, D.C. 20008

19 Nov. 1978

Dear Tom:

Got the fleas all mounted and identified as follows;

Fox #337	12 March 1978	*Pulex irritans*, 1 male
Fox #336	12 March 1978	*Pulex irritans*, 4 males; 9 females.
Fox #338	12 March 1978	*Pulex irritans*, 1 male.
Fox #339	12 March 1978	*Pulex irritans*, 1 male; 4 females.
Fox #340	12 March 1978	*Pulex irritans*, 3 males; 9 females.
Fox #341	12 March 1978	*Pulex irritans*, 5 males; 8 females.
Fox # 344	12 March 1978	*Pulex irritans*, 5 males; 8 females. *Echidnophaga gallinacea*, 4 males; 1 female. *Orchopeas leucopus*, 1 male.

An inbalance in favor of females for *P. irritans* is about the same in this small sample from kit foxes in KERN COUNTY, CALIF. as it was from a much larger sample from TOOELE COUNTY, UTAH, kit foxes. The most interesting collection was from #344. *Orchopeas leucopus* is normally found on *Peromyscus* and harvest mice and was probably acquired from a prey species by the fox. *E. gallinacea* has been recorded from a wide variety of mammalian hosts in southern Calif. but is often a serious pest of poultry. It was reported from *V.m.arsipus* collected at Pisgah, 40 miles east of Barstow, by G.F.Augustson, 1943. This flea is apparently able to maintain itself in the absence of avian hosts.

I found I was a little out of practice at mounting fleas, which is a rather exacting task. But it was fun and I intend doing a lot more of it once we are back west.

If you have any more fleas to identify maybe you can hang on to them until we are moved to Utah. If there is a real rush, I can identify the *Pulex irritans* without mounting them.

Best regards to Joan and Larry.

Sincerely,

Harold

Harold J. Egoscue
Mammalogist

Appendix 5. Tortoise observations and measurements. We kept records of the locations, numbers, and measurements of desert tortoises observed during the course of the kit fox study. Table 15 contains a summary of these observations and it is appended. For many tortoises we have provided measurements of the greatest length and width of their carapace; for others we have provided estimates of the lengths only.

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Table 15. Observations and measurements of Desert Tortoise observed on the Rand and Desert Tortoise areas, Kern County, California, 1978.

Date	Area	No.	Measurements (cm)
March	Rand	2	25 x 20 (2)
	Tortoise	7	30 x 25; 25 x 20 (2); 20 x 15
April	Rand	6	21 x 17; 22 x 18 (2); 24 x 20 (3)
	Tortoise	19	13 x 10; 15 x 13; 21 x 17 (2); 21 x 18; 22 x 18; 23 x 19; 23 x 20; 25 x 21; 26 x 22 (2); 27 x 24; 30 x 26
May	Rand	3	8 x 5; 17 x 13; 18 x 15
	Tortoise	6	6 x 3; 12 x 9; 17 x 13; 20 x 16; 21 x 17; 24 x 19
June	Rand	7	19 x 15; 21 x 17; 22 x 18 (2); 24 x 20; 28 x 24; 30 x 26
	Tortoise	21	7 x 4; 10 x 6; 14 x 10; 17 x 13; 20 x 30 (11); 24 x 20; 25 x 21 (2); 28 x 24; 28 x 25; 30 x 26
July	Rand	10	10 x 6; 11 x 8; 15 x 11; 16 x 12; 19 x 15; 23 x 19; 24 x 20 (3)
	Tortoise	5	10 x 7 (2); 11 x 7 (2); 24 x 20
August	Rand	4	21 x 17 (3); 30 x 26
September	Tortoise	11	Lengths only: 5; 6; 15 (2); 20 (3); 23 (2); 30 (3)
October	Tortoise	8	Lengths only: 20 (2); 23 (3); 24 (2); 26
Totals	Rand	32	
	Tortoise	77	

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